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(54) **Electronic equipment, and reception control method of electronic equipment**

(57) To provide an electronic equipment capable of outputting substantially correct time data even when correct time information based on external radio information cannot be acquired. A radio wave correction timepiece comprises an antenna 21 for receiving external radio information including time information, a reception circuit 22, and a time counter 53 for counting the internal time. A control circuit 24 of a timepiece comprises a comparison circuit 54 for comparing received external time data with internal time data to output the difference, a reception information storage unit 71 in which at least a plurality of sets of the reception timing of external radio information and each data on the difference are stored, a correction calculation unit 62 for calculating the estimated correction by the plurality of reception timing data, difference data, and the elapsed time from the last reception, and an internal time correction control unit 61 for correcting the internal time using the estimated correction.

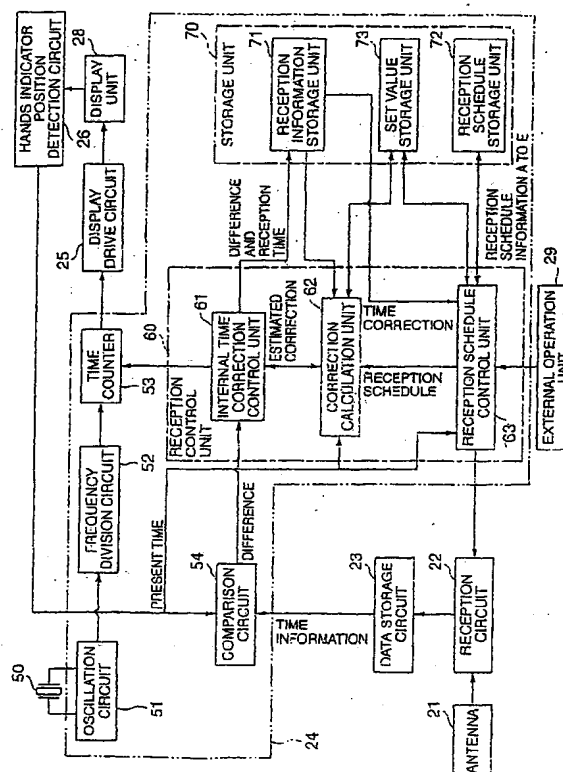


FIG. 2

## Description

**[0001]** The present invention relates to an electronic equipment for receiving external radio information to perform the correction, etc. of the operation, and a reception control method of the electronic equipment, and more specifically, it relates to an electronic equipment represented by a radio wave correction timepiece for receiving external time information, and performing the time correction, and a reception control method of the electronic equipment.

**[0002]** Widely known electronic equipment for receiving external radio information to correct the operation thereof, etc. includes a radio wave correction timepiece for receiving external time information to perform time correction.

**[0003]** Such a radio wave correction timepiece has a forced reception function of performing the forced reception to forcibly receive the standard wave by operating a winding crown or a button by a user, and an automatic reception function of performing automatic time correction of the preset time of reception, for example, by receiving the standard wave at, for example, two o'clock in the morning every day.

**[0004]** Incidentally, the accuracy of quartz timepieces in recent years is generally  $\pm 20$  seconds or under in Loss/Gain Monthly-rate, and the accuracy of some of highly accurate ones is  $\pm 10$  seconds or under in Loss/Gain Yearly-rate. Thus, little error can occur during the daily operation, and time correction has been often unnecessary even when receiving the standard wave.

**[0005]** As a result, time correction need not be performed, and radio wave reception operation has been wastefully operated, and the power is wastefully consumed. In particular, the reception is an operation of consuming the most power in timepieces, and there occurs a problem in that the service life of a battery is shortened in, for example, a wristwatch driven by a battery.

**[0006]** In order to avoid wasteful power consumption, a technique has been known, in which the reception interval is changed according to time correction by radio wave reception at a certain time (for example, refer to the Patent Reference 1).

[Patent Reference 1]

**[0007]** Japanese Laid-open Patent Application Publication No. Hei7-159559

**[0008]** However, if electromagnetic noise is generated by the external magnetic field or an internal generator, the noise affects external radio information, and in some cases, correct time information cannot be acquired. Further, when external radio information is received, correct time information cannot be acquired if a user, by chance, is within a building, a subway, an underground passage, etc. where it is very hard to receive a radio wave and the user cannot receive the radio wave. In the invention disclosed in the above Japanese

Laid-open Patent Application Publication, there occur problems in that since time information cannot be acquired, the internal time cannot be corrected by time information in such cases, and correct time data is less easily output.

**[0009]** This problem occurs not only in the radio wave correction timepiece, but also various kinds of electronic equipment for controlling specific operations by using correct time information such as personal computers, electronic toys, and timers.

**[0010]** The first object of the present invention is to provide an electronic equipment and a reception control method of the electronic equipment, capable of outputting substantially correct time data even when correct time information based on external radio information cannot be acquired.

**[0011]** In addition, in the invention in the above Japanese Laid-open Patent Application Publication, the next reception timing is determined by the correction quantity at a certain time point without taking into consideration any circumferential changes such as the characteristic, service environment, and secular changes of an electric circuit, and if the correction quantity in one radio wave reception is very small by chance, reception in each hour can be received after at most 24 hours. Thus, there is a possibility that the time of the equipment is largely deviated (Loss/Gain) before the next reception, and there occurs a problem in that correct time cannot be displayed.

**[0012]** The second object of the present invention is to provide an electronic equipment and a reception control method of the electronic equipment, capable of outputting more correct time data while reducing the power consumption required in reception.

**[0013]** In addition, according to the invention disclosed in the above Japanese Laid-open Patent Application Publication, indication error is easily generated if the correction quantity is large, and this problem is dealt with only by shortening the reception interval of the radio wave. Thus, there occur problems in that the number of radio wave reception is not reduced on a whole as expected, and the reduction effect of power consumption is limited.

**[0014]** The third object of the present invention is to provide an electronic equipment and a reception control method of the electronic equipment, capable of reducing the power consumption required in reception and outputting correct time data even when correction quantity is large in addition to the second object.

**[0015]** The electronic equipment of the present invention comprises an external radio information reception unit for receiving external radio information including time information, an internal time measuring unit for measuring the internal time based on the reference clock, a time data comparison unit for comparing external time data forming time information received by the external radio information reception unit with internal time data measured by the internal time measuring unit

to output the difference therebetween, a storage unit, and a reception control unit, wherein the storage unit has a reception information storage unit storing at least a plurality of sets of each data on the timing of receiving the external radio information by the external radio information reception unit and the difference thereof, and wherein the reception control unit comprises a correction calculation unit for calculating the estimated correction by the plurality of sets of reception timing data, difference data, and the elapsed time from the last reception, and an internal time correction control unit for correcting the internal time by using the estimated correction.

**[0016]** In the present invention, when external radio information is received by the external radio information reception unit, the received time information is compared with the internal time data measured based on the reference clock prepared inside the electronic equipment by the time data comparison unit, the difference therebetween is output, and the data including the difference and the reception timing is stored in the reception information storage unit.

**[0017]** In addition, the present invention includes the internal time correction control unit for calculating the estimated correction by a plurality of sets of last reception timing and difference based on the last reception data, and correcting the internal time by the value, and the internal time can be corrected based on the estimated correction even when time information based on external radio information cannot be acquired, or even when a user wishes to perform time correction at an arbitrary time without receiving external radio information, and generation of large time deviation can be suppressed.

**[0018]** Cases in which time information is unsuccessfully acquired (cannot be acquired) mean a case in which a user cannot receive external radio information when he wishes to receive external radio information because he is within a building, a subway, etc. by chance, a case in which time information cannot be acquired because external radio information cannot be received due to the effect of electromagnetic noise inside and outside the electronic equipment, and a case in which correct time information could not be acquired because noise is superposed on external radio information, and erroneous data is received. Therefore, the internal time correction control unit preferably corrects the internal time by using the estimated correction when time information by receiving external radio information by, for example, the external radio information reception unit is unsuccessfully acquired.

**[0019]** In the present invention, the reception control unit has a reception schedule control unit for controlling the reception schedule in the external radio information reception unit, and wherein the internal time correction control unit preferably corrects the internal time by using the estimated correction when time information is unsuccessfully acquired in case external radio information

is received based on the reception schedule.

**[0020]** According to the present invention, even when the time information based on radio information is unsuccessfully acquired in case automatically external radio information is received by the reception schedule control unit, the internal time can be corrected by the estimated correction, and generation of large time deviation can be suppressed.

**[0021]** In the present invention, the reception control unit has a reception schedule control unit for controlling the reception schedule in the external radio information reception unit, and the internal time correction control unit preferably corrects the internal time by using the estimated correction when reception is not performed though at the reception timing on the initially set reception schedule because the reception schedule is changed by the reception schedule control unit.

**[0022]** According to the present invention, time correction is performed using the estimated correction when reception is not performed at the timing for radio wave reception at the initial reception schedule, and substantially similar time accuracy to that with radio wave reception can be ensured without performing radio wave reception, and correct time data can be output.

**[0023]** In the present invention, the electronic equipment has an external operation unit for instructing the forced reception of external radio information by the external radio information reception unit, and the internal time correction control unit also corrects the internal time by using the estimated correction when time information by receiving the external radio information is unsuccessfully acquired in case the forced reception is instructed by operating the external operation unit by a user.

**[0024]** According to the present invention, even when time information based on the radio information is unsuccessfully acquired during the forced reception by manual operation, the internal time can be corrected with the estimated correction, and generation of large time deviation can be suppressed.

**[0025]** In the present invention, the electronic equipment has a magnetic field detection unit for detecting electromagnetic noise, and the reception control unit preferably has a reception processing control unit for prohibiting reception operation or invalidating reception data by the external radio information reception unit when detecting electromagnetic noise by the magnetic field detection unit.

**[0026]** According to the present invention, time information received by the external radio information reception unit is compared with internal time data by a time data comparison unit to output the difference therebetween, and the data including this difference and the reception timing is stored in the reception information storage unit.

**[0027]** In this case, electromagnetic noise such as high frequency noise and AC wave noise from the outside, and electromagnetic noise generated by the power

generation by a generator when an electromagnetic generator generates the power when the electromagnetic generator is built in the electronic equipment, during radio wave reception, affects the external radio information reception unit, and then leading to a possibility that external radio information cannot be received, or noise is superposed on the radio information to receive erroneous data.

**[0028]** In the present invention, the reception control processing unit for prohibiting reception operation or invalidating reception data when detecting electromagnetic noise by the magnetic field detection unit is provided, and time correction, etc. based on external radio information affected by the noise, when electromagnetic noise is generated, is prevented from being performed.

**[0029]** In addition, even when time information cannot be acquired from external radio information due to the effect of electromagnetic noise, the estimated correction is calculated based on the last reception data, i.e., by the plurality of sets of last reception timing and difference quantity by the correction calculation unit and the internal time correction control unit, the internal time is corrected thereby, and generation of large time deviation can be suppressed.

**[0030]** In the present invention, the reception control unit comprises a reception schedule control unit for controlling the reception schedule in the external radio information reception unit, and, in case external radio information is received based on the reception schedule, the internal time correction control unit preferably corrects the internal time by using the estimated correction in case electromagnetic noise is detected by the magnetic field detection unit, and reception operation is prohibited or reception data is invalidated by the reception processing control unit, when time information is unsuccessfully acquired.

**[0031]** In addition, the electronic equipment of the present invention comprises an external operation unit for instructing the forced reception of external radio information by the external radio information reception unit, and, in case the forced reception is instructed by operating the external operation unit by a user, the internal time correction control unit corrects the internal time by using the estimated correction in case electromagnetic noise is detected by the magnetic field detection unit, and reception operation is prohibited or reception data is invalidated by the reception processing control unit, when time information is unsuccessfully acquired.

**[0032]** The internal time can be corrected by the estimated correction even when radio information with electromagnetic noise detected therein cannot be received during the automatic reception of external radio information by the reception schedule control unit or during the forced reception by manual operation, or reception data is invalidated, and time information cannot be acquired, and generation of large time deviation can be suppressed.

**[0033]** The electronic equipment of the present invention comprises an external radio information reception unit for receiving external radio information including time information, an internal time measuring unit for measuring the internal time based on the reference clock, a time data comparison unit for comparing external time data forming time information received by the external radio information reception unit with internal time data measured by the internal time measuring unit to output the difference therebetween, a storage unit, and a reception control unit, wherein the storage unit comprises a reception information storage unit storing at least a plurality of sets of each data on the timing of receiving the external radio information by the external radio information reception unit and the difference thereof, and wherein the reception control unit comprises a reception schedule control unit for controlling the reception schedule in the external radio information reception unit based on the plurality of sets of reception timing data and difference data stored in the reception information storage unit.

**[0034]** According to the present invention, the external radio information reception unit is operated according to the predetermined reception schedule by the reception schedule control unit, and receives external radio information. The received time information is compared with internal time data by the time data comparison unit to output the difference therebetween, and the data on the difference thereof and the reception timing are stored in the reception information storage unit.

**[0035]** The reception schedule control unit controls (changes) the reception schedule based on the respective data on the difference thereof and the reception timing. As described above, in the present invention, the future (next) reception schedule is controlled by using a plurality of sets of data received in the past, and compared with the case in which the reception interval is changed by only one reception data, the tendency of measuring error can be reliably grasped, and the reception interval can be adjusted. Thus, the possibility of error occurrence can be reduced, and deviation in time data output to a display unit can be minimized. In addition, since the reception interval can also be increased by changing the reception schedule, power consumption can be reduced, and in a case of a battery-driven system, the service life of a battery can be prolonged.

**[0036]** Here, a correction calculation unit for calculating the estimated correction by the plurality of sets of reception timing data, difference data, and the elapsed time from the last reception, and an internal time correction control unit for correcting the internal time by using the estimated correction are preferably provided.

**[0037]** In such a configuration, the estimated correction based on the difference and the reception timing is calculated even when the reception interval is increased, and time correction can be performed by the estimated correction, and only time correction can be performed without reception of the radio wave if the re-

ception interval of the radio wave is increased, and the error in internal time data can be reduced.

[0038] The internal time correction control unit preferably corrects the internal time by using the estimated correction when reception is not performed, though at the reception timing according to the initially set reception schedule because the reception schedule is changed.

[0039] In such a configuration, time correction is performed using the estimated correction when reception is not performed at the timing for radio wave reception according to the reception schedule, and the time accuracy substantially similar to that with radio wave reception can be ensured even when radio wave reception is not performed, and correct time data can be output.

[0040] In the present invention, the reception schedule control unit preferably changes the reception schedule so that the reception interval is longer than the initially set value when the average value of the time correction value per unit time, obtained by the reception timing and difference thereof, is small and equal to or less than the first set value for the average value, and/or when the dispersion in the time correction value is small and equal to or less than the first set value for the dispersion.

[0041] In case the average value of the time correction value per unit time is small, the error therein can be suppressed to be small even when the time for no reception is prolonged. In case the dispersion in the time correction value is small and equal to or less than the first set value for the dispersion, the error can be suppressed to be small by using the estimated correction even when the radio wave cannot be received.

[0042] Here, the first set value for the average value and the first set value for the dispersion may be appropriately set during the implementation, and for example, set according to the time accuracy, etc. requested for the electronic equipment. For example, when the accuracy of about 10 to 20 seconds in Loss/Gain Monthly-rate is obtained, the first set value for the average value may be equal to or less than 10 to 20 seconds/30 days in Loss/Gain Monthly-rate in terms of the time correction value per day, more specifically, about 0.25 second/day. The first set value for the dispersion is generally set to be smaller than the first set value for the average value, and may be set to be, for example, equal to or less than one half of the first set value for the average value, more specifically, about 0.1 second/day.

[0043] The reception interval may be set to be longer than the initial set value either when the average value of the time correction value is small and equal to or less than the first set value for the average value, or when the dispersion of the time correction value is small and equal to or less than the first set value for the dispersion. However, in case the time indication error is reliably reduced, the reception schedule may be changed so that the reception interval is longer than the initial set value when the average value of the time correction value is

equal to or less than the first set value for the average value, and the dispersion of the time correction value is small and equal to or less than the first set value for the dispersion.

[0044] Accordingly, the reception interval can be set to be long, and the power consumption can be considerably reduced. While the error is small, and radio wave reception is not performed, time correction is not necessarily performed with the estimated correction, and power consumption can be reduced from this point.

[0045] In addition, in the present invention, the reception schedule control unit preferably changes the reception schedule so that reception interval is longer than the initially set value by skipping the reception timing in the initially set reception schedule for at least once. For example, in a schedule for reception once in a day in the initially set value, reception once may be skipped to the schedule of reception once in two days, or reception twice may be skipped to the schedule of reception once in three days.

[0046] In such a change of the reception schedule, the reception schedule can be easily changed.

[0047] In addition, in the present invention, the reception schedule control unit preferably changes the reception schedule so that the reception interval is shorter than the initial set value in case the average value of the time correction value per unit time, obtained with the reception timing and the difference thereof, is large and equal to or greater than the second set value for the average value, and/or in case the dispersion in the time correction value for each reception timing is large and equal to or greater than the second set value for the dispersion.

[0048] In case the average value of the time correction value is equal to or greater than the second set value for the average value, or "dispersion" is large and equal to or greater than "the second set value for the dispersion," the fluctuation per unit time is large, and there is a possibility that error occurs even when corrected with the estimated correction.

[0049] According to the present invention, even in such a case, the fluctuation can be reliably grasped and time correction can be performed, and the time accuracy can be improved by increasing the number of actual reception of the radio wave.

[0050] Here, the second set value for the average value may be equal to or greater than at least the first set value for the average value, the second set value for the dispersion may be equal to or greater than at least the first set value for the dispersion, and the specific value may be appropriately set in implementation. For example, each second set value is set to be equal to or less than two times each second set value, for example, about 1.2 to 1.5 times.

[0051] In case either the average value of the time correction value is large and equal to or greater than the second set value for the average value, or the dispersion in the time correction value is large and equal to or great-

er than the second set value for the dispersion, the reception interval may be shorter than the initially set value. However, in case the average value of the time correction value is equal to or greater than the second set value for the average value, and in case the dispersion in the time correction value is large and equal to or greater than the second set value for the dispersion, the reception schedule may be changed so that the reception interval is shorter than the initially set value.

**[0052]** As described above, in case the reception interval is set to be shorter only when both conditions are satisfied, priority can be given to suppression of the increase in power consumption required in reception compared with the improvement of the time accuracy by shortening the reception interval, and this method is effective when providing a power-saving mode, etc.

**[0053]** Here, in the present invention, the dispersion in the time correction value means the deviation to the regression equation when obtaining the regression formula (the regression equation) by each time correction value. The regression formula is generally a regression curve obtained by the least square method, but may be the regression curve such as a sine curve and a quadratic curve according to data.

**[0054]** Here, in the present invention, the storage unit has a reception schedule storage unit storing a plurality of sets of reception schedule information in an external radio information reception unit, and the reception schedule control unit preferably controls the reception schedule by selecting reception schedule information of the reception schedule storage unit.

**[0055]** In such a configuration, the schedule can be changed only by selecting reception schedule information, and the control thereof can be easily performed. In addition, the reception schedule storage unit for storing the selected reception schedule information is provided, and thus, schedule information of a user or when shipped from a factory can be set and stored, and the selected reception schedule information can be easily set and changed. Therefore, schedule information can be set according to the utilization situation of users and the kind of the electronic equipment, and optimum schedule control can be performed.

**[0056]** In the present invention, the internal time correction control unit preferably corrects the internal time by using the estimated correction in case the estimated correction calculated by the correction calculation unit is large and equal to or greater than the correction determination value.

**[0057]** In such a configuration, the time is corrected only when the estimated correction is large. In case the estimated correction is small and less than the correction determination value, and no indication error occurs, neither radio wave reception nor time correction is performed, and power consumption can be more reduced.

**[0058]** Here, in the present invention, a plurality of sets of reception timing data and difference data stored in the reception information storage unit are preferably

the data of the latest predetermined number out of a plurality of sets of data received in the past.

**[0059]** In such a configuration, when the reception schedule and the estimated correction are set by using reception timing data and difference data for seven times in the past, the average value of the time correction value and the estimated correction can be calculated based on the recent tendency with the data for seven times in the past including the latest data in case new reception is performed, and the accuracy thereof can be improved.

**[0060]** The data for the predetermined times in the past need not be the continuously received data. This means that unsuccessful radio wave reception in the past attributable to the effect of electromagnetic noise, etc. may not be acceptably included, and the radio wave may be received predetermined times including the times therearound, and the data may be stored.

**[0061]** In the present invention, a setting changing unit for changing the setting of at least one of each set value and each determination value out of the respective set values and determination values is preferably provided.

**[0062]** By providing such a setting changing unit, a user can freely change and set each set value and determination value used for each determination according to the service situation and the external environment, and more appropriate control can be performed thereby.

**[0063]** And, in the present invention, the electronic equipment is preferably a radio wave correction timepiece having a display unit to indicate the internal time measured by the internal time measuring unit.

**[0064]** In this case, the display unit corrects the indication time according to correction of the internal time by using the estimated correction by the internal time correction control unit.

**[0065]** In case the electronic equipment of the present invention is applied to the radio wave correction timepiece, power consumption can be reduced, the service life can be prolonged even in a battery-driven mode, the accuracy of the indication time can be improved, and a timepiece of small error can be realized.

**[0066]** A reception control method of the electronic equipment of the present invention is a reception control method of the electronic equipment having an external radio information reception unit for receiving external radio information including time information and an internal time measuring unit for measuring the internal time based on the reference clock, and comprises a time data comparison step of comparing external time data forming time information received by the external radio information reception unit with internal time data measured by the internal time measuring unit and outputting the difference therebetween, a reception information storage step of storing at least a plurality of sets of each data on the timing of receiving the external radio information by the external radio information reception unit and the difference thereof, a correction calculation step

of calculating the estimated correction by the plurality of sets of reception timing data, difference data, and the elapsed time from the last reception, and an internal time correction control step of correcting the internal time by using the estimated correction.

**[0067]** In the present invention, when external radio information is received by the external radio information reception unit, the received time information is compared with the internal time data measured based on the reference clock formed inside the electronic equipment in the time data comparison step, the difference therebetween is output, and the data of the difference thereof and the reception timing is stored in the reception information storage step. In addition, in the correction calculation step, the estimated correction is calculated based on the reception data in the past, i.e., by the data of the plurality of sets of the reception timing, difference, the elapsed time, etc. in the past, and in the internal time correction control step, the internal time is corrected by the estimated correction.

**[0068]** Thus, for example, when a user wishes to perform the time correction without receiving external radio information at an arbitrary time, the internal time can be corrected based on the estimated correction, and generation of large time deviation can be suppressed.

**[0069]** A reception control method of the electronic equipment of the present invention is a reception control method of the electronic equipment having an external radio information reception unit for receiving external radio information including time information and an internal time measuring unit for measuring the internal time based on the reference clock, and comprises a time data comparison step of comparing external time data forming time information received by the external radio information reception unit with internal time data measured by the internal time measuring unit and outputting the difference therebetween, a reception information storage step of storing at least a plurality of sets of each data on the timing of receiving the external radio information by the external radio information reception unit and the difference thereof, a correction calculation step of calculating the estimated correction by the plurality of sets of reception timing data, difference data, and the elapsed time from the last reception, and an internal time correction control step of correcting the internal time by using the estimated correction in case time information is successfully acquired when receiving external radio information by the external radio information reception unit.

**[0070]** According to the present invention, even when time information based on external radio information cannot be acquired such as when external radio information is unsuccessfully received, the internal time can be corrected based on the estimated correction, and generation of large time deviation can be suppressed.

**[0071]** A reception control method of the electronic equipment of the present invention is a reception control method of the electronic equipment having an external

radio information reception unit for receiving external radio information including time information and an internal time measuring unit for measuring the internal time based on the reference clock, and comprises a time data comparison step of comparing external time data forming time information received by the external radio information reception unit with internal time data measured by the internal time measuring unit and outputting the difference therebetween, a reception information storage step of storing at least a plurality of sets of each data on the timing of receiving the external radio information by the external radio information reception unit and the difference thereof, a correction calculation step of calculating the estimated correction by the plurality of sets of reception timing data, difference data, and the elapsed time from the last reception, a magnetic field detection step of detecting electromagnetic noise, a reception control step of prohibiting reception operation or invalidating reception data by the external radio information reception unit when detecting electromagnetic noise by the magnetic field detection step, and an internal time correction control step of correcting the internal time by using the estimated correction when prohibiting the reception operation or invalidating reception data in the reception control step.

**[0072]** According to the present invention, even when electromagnetic noise is detected, reception of external radio information is prohibited, or reception data is invalidated, the internal time can be corrected based on the estimated correction, and generation of large time deviation can be suppressed.

**[0073]** The reception control method of the electronic equipment of the present invention is a reception control method of the electronic equipment comprising an external radio information reception unit for receiving external radio information including time information, and an internal time measuring unit for measuring the internal time based on the reference clock, and comprises a time data comparison step of comparing external time data forming time information received by the external radio information reception unit with internal time data measured by the internal time measuring unit to output the difference therebetween, a reception information storage step of storing at least a plurality of sets of each data on the timing of receiving the external radio information by the external radio information reception unit and the difference thereof, and a schedule control step of controlling the reception schedule in the external radio information reception unit based on the plurality of sets of reception timing data and difference data stored in the reception information storage unit.

**[0074]** The reception control method preferably comprises a correction calculation step of calculating the estimated correction by the plurality of sets of reception timing data, difference data, and the elapsed time from the last reception, and an internal time correction control step of correcting the internal time by using the estimated correction.

[0075] Each reception control method has the same operational advantages as those of each invention of the electronic equipment including the above operational advantages.

[0076] Embodiments of the present invention will now be described by way of further example only and with reference to the accompanying drawings, in which:-

Fig. 1 shows the configuration of a radio wave correction timepiece according to the first embodiment of the present invention.

Fig. 2 is a block diagram of the configuration of a control circuit according to the first embodiment.

Fig. 3 shows the data configuration of a reception information storage unit according to the first embodiment.

Fig. 4 shows the data configuration of a reception schedule storage unit according to the first embodiment.

Fig. 5 is a flowchart showing the operation of a control circuit according to the first embodiment.

Fig. 6 is a flowchart showing the change of the reception schedule according to the first embodiment.

Fig. 7 is a flowchart showing the prolongation of the reception interval according to the first embodiment.

Fig. 8 is a flowchart showing the time correction in the estimated correction according to the first embodiment.

Fig. 9 is a graph showing the elapsed change of the time correction according to the first embodiment.

Fig. 10 is a block diagram showing the configuration of a control circuit according to the second embodiment of the present invention.

Fig. 11 is a flowchart showing the operation of the control circuit according to the second embodiment.

Fig. 12 is a flowchart showing the time correction in the estimated correction according to the second embodiment.

Fig. 13 is a block diagram showing the configuration of a control circuit according to a third embodiment of the present invention.

Fig. 14 is a flowchart showing the operation of the control circuit according to the third embodiment.

Fig. 15 is a graph showing the elapsed change of the time correction in a modification of the present invention.

Fig. 16 is a graph showing the elapsed change of the time correction in another modification of the present invention.

Fig. 17 is a graph showing the elapsed change of the time correction in a still another modification of the present invention.

[First Embodiment]

[0077] Fig. 1 shows the circuit configuration of a radio wave correction timepiece 1 according to a first embodiment.

ment.

[0078] The radio wave correction timepiece 1 comprises an antenna 21 for receiving the standard long wave (external radio information) with time information superposed thereon, a reception circuit 22 as a receiving means which processes the standard long wave by the antenna 21 and outputs it as time information (time code), a data storage circuit 23 for storing time information output from the reception circuit 22, a control circuit 24, a display drive circuit 25 for controlling the drive of a display unit 28 to display the time, hands indicator position detection circuit 26 for detecting the hands position of an indicator of the display unit 28, a battery 27 as a power source for driving each circuit, and the display unit 28 comprising indicators such as an hour hand, a minute hand, and a second hand, and a motor for driving the indicators.

[0079] The antenna 21 comprises a ferrite antenna with a coil around a ferrite rod.

[0080] The reception circuit 22 comprises an amplifier circuit, a band pass filter, a demodulator circuit, and a decoding circuit (which are not shown), and captures time information (time code), which are digital data, from the received radio waves, and stores it in the data storage circuit 23.

[0081] Thus, an external radio information reception unit comprises the antenna 21, the reception circuit 22, and the data storage circuit 23.

[0082] Time information stored in the data storage circuit 23 is processed by the control circuit 24. Fig. 2 shows the configuration of this control circuit 24.

[0083] The control circuit 24 comprises an oscillation circuit 51, a frequency division circuit 52, a time counter 53, a comparison circuit 54, a reception control unit 60, and a storage unit 70.

[0084] The reception control unit 60 comprises an internal time correction control unit 61, a correction calculation unit 62, and a reception schedule control unit 63.

[0085] The storage unit 70 comprises a reception information storage unit 71, a reception schedule storage unit 72, and a set value storage unit 73.

[0086] The oscillation circuit 51 performs the high frequency oscillation of the reference oscillation source 50 such as a quartz oscillator, the frequency division circuit 52 divides its oscillation signal, and outputs it as a predetermined reference signal (for example, a signal of 1 Hz). The time counter 53 counts this reference signal to measure the present time.

[0087] Thus, the internal time measuring unit for measuring the internal time comprises these circuits 51 and 52, and the counter 53. Every time the time counter 53 counts up one, the drive signal is output to the display drive circuit 25 to drive the display unit 28 comprising an indicator and a stepping motor.

[0088] The position of the indicator is detected by the hands indicator position detection circuit 26, and output to the comparison circuit 54.

[0089] The comparison circuit 54 determines whether



or not time information (external time data) is correct time data, and outputs the difference between the time information and the position of the hands indicator position detection circuit 26, i.e., internal time data (present time data) if the time information is correct time data. Thus, a time data comparison unit is constituted by the comparison circuit 54.

[0090] Various kinds of methods used in a conventional radio wave correction timepiece can be employed in a method for determining whether or not the received time information is correct. For example, a method for checking the correct time data can be employed, from the points that the hour or the day is unrealistic such as 68 minutes, and each set of time data indicates the expected time, i.e., each data indicates such a time because it is estimated that the time data is the one for each minute if it is continuously received.

[0091] In the present embodiment, indicator position data of the hands indicator position detection circuit 26 is used for internal time data, but output data of the time counter 53 may also be used. In this case, the output of the time counter 53 may be input not only in the display drive circuit 25 but also in the comparison circuit 54. If such a configuration is employed, the hands indicator position detection circuit 26 need not be necessarily provided.

[0092] The internal time correction control unit 61 corrects the value of the time counter 53 based on the difference output from the comparison circuit 54, and corrects the time display of the display unit 28 via the display drive circuit 25. The internal time correction control unit 61 further stores each data at the timing of receiving the difference and the time correction timing, i.e., the timing of receiving external radio information, in the reception information storage unit 71.

[0093] As shown in Fig. 3, each data of the reception timing and the difference are stored in the reception information storage unit 71 from the latest reception timing tracing back to seven sets of data in the past. Further, the time correction value (second/day) obtained by the difference (second)/the reception interval (day) is also operated and stored. In Fig. 3, data on the date "2002/4/3" is not described. This is because the difference in the previous day "2002/4/2" is small, the reception of "2002/4/3" is skipped, and as a result, data is not present.

[0094] The correction calculation unit 62 calculates the estimated correction using a plurality of sets of data stored in the reception information storage unit 71. For example, a regression equation for regression line, etc. is obtained by using least square of data of seven time correction values, and the estimated correction after a predetermined elapsed time from the latest reception timing, for example, after one day is calculated based on the regression equation.

[0095] The reception schedule control unit 63 selects a reception processing schedule at the reception circuit 22 from each schedule information stored in the recep-

tion schedule storage unit 72, and changes it.

[0096] This means that, in the present embodiment, five kinds of reception schedule information including schedule information A to E is registered in advance in the reception schedule storage unit 72 as shown in Fig. 4. The reception schedule control unit 63 selects appropriate reception schedule information A to E based on the data stored in the reception information storage unit 71, and controls the operation of the reception circuit 22 based on the information A to E.

[0097] In the present embodiment, the reception schedule control unit 63 selects each set of reception schedule information A to E based on the average value of the time correction value and dispersion (the deviation from the regression equation) in the time correction value stored in the reception information storage unit 71 as described below.

[0098] Change of the schedule in the reception schedule control unit 63 is also notified to the correction calculation unit 62, and the correction calculation unit 62 instructs the time correction to the internal time correction control unit 61 according to the reception schedule and the estimated correction.

[0099] More specifically, the reception schedules B to D are selected, the reception once in a day is skipped, and if radio wave reception is not performed at two o'clock in the morning which is the original reception timing, the estimated correction is calculated at the time, and the time correction is performed with the estimated correction if the correction is not less than the correction determination value, for example, not less than 0.2 second. On the other hand, the time correction is not performed if the correction is below the correction determination value.

[0100] When a user instructs the forced reception by operating the external operation unit 29 such as a winding crown and a button, the reception schedule control unit 63 operates the reception circuit 22 immediately irrespective of the reception schedule, and receives external radio information.

[0101] The set value storage unit 73 stores respective set values (the first and second set values for the average value, and the first and second set values for dispersion) used for the determination in the reception schedule control unit 63, and the correction determination value used in the correction calculation unit 62.

[0102] The operation of the radio wave correction timepiece 1 of this configuration will be described with reference to flowcharts in Figs. 5 to 8.

[0103] The control circuit 24 measures the present time by counting the reference clock such as 1 Hz output via the oscillation circuit 51 and the frequency division circuit 52 by the time counter 53 in a normal state. As the counter value of the time counter 53 is changed, the drive pulse is output to a stepping motor of the display unit 28 from the display drive circuit 25, and each indicator is operated thereby.

[0104] On the other hand, when the reception control

unit 60 starts the operation, the variable N1 indicating the number of reception is set to be the initial value zero, and the variable N2 indicating the selected reception schedule is set to be the initial value zero (Step 1; hereinafter, Step is abbreviated as "S"). In addition, the reception schedule control unit 63 selects reception schedule information A on the initial set values among reception schedule information A to E stored in the reception schedule storage unit 72, and controls it by the schedule for receiving radio wave once in a day (S2).

[0105] Successively, the reception schedule control unit 63 determines whether or not the forced reception is instructed by the external operation unit 29 (S3A). If the forced reception is not instructed, whether or not the reception timing is reached is determined (S3B). If the forced reception is instructed (S3A), or the reception timing is reached (S3B), the reception schedule control unit 63 drives the reception circuit 22 to perform the radio wave reception (S4).

[0106] For example, at the time immediately after the start, schedule information A (once/day) forming the initial set value is set, and at the time when the present time detected by the hands indicator position detection circuit 26 is set, for example, at two o'clock in the morning every day, the reception schedule control unit 63 drives the reception circuit 22 to perform radio wave reception (S4).

[0107] When the reception circuit 22 is operated, the standard wave is received by the antenna 21, and time data (time information) is stored in the data storage circuit 23 via the reception circuit 22. The reception schedule control unit 63 operates the reception circuit 22 for about three minutes, and stops the reception circuit 22 when it receives time information for three frames.

[0108] The comparison circuit 54 checks that time information stored in the data storage circuit 23 is correct time data, and determines whether or not reception is successful (S5).

[0109] When it is determined that reception is successful in S5, the comparison circuit 54 calculates the difference between received time information and the present time detected by the hands indicator position detection circuit 26, and outputs it to the internal time correction control unit 61.

[0110] The internal time correction control unit 61 corrects the data of the time counter 53 by using the difference data, and corrects the present time display of the display unit 28 via the display drive circuit 25 (S6).

[0111] In addition, the internal time correction control unit 61 stores the difference, i.e., the time correction data, and the time of reception, i.e., the correction timing data in the reception information storage unit 71 (S7).

[0112] The reception control unit 60 adds 1 to the reception number N1 because the first reception is performed (S8), and determines whether or not the reception number N1 is not less than the predetermined value, i.e., not less than 7 in the present embodiment (S9).

[0113] If N1 is less than 7 in S9, or it is determined by

the comparison circuit 54 that reception is unsuccessful in S5, it is waiting for the forced reception (S3A) or the reception timing (S3B), and then, when the forced reception is instructed, and when the reception timing is reached, the above sets of processing S4-S9 are repeated.

[0114] On the other hand, if the reception number N1 is determined to be not less than 7 in S9, the reception control unit 60 changes the reception schedule by the reception schedule control unit 63 (S10), and the time correction with the estimated correction is performed by the correction calculation unit 62 (S11).

[0115] Sets of processing in S3A, S3B and subsequent ones are repeated based on the changed reception schedule.

[0116] In the present embodiment, a set of processing in S10 and S11 is set to be performed after the case in which N1 is not less than 7, this means, reception for seven times is performed from the start in S9, but this number of determination is not limited to seven, and may be appropriately set to 3, 5, 10, etc. during the implementation.

[0117] In addition, in the present embodiment, after reception of eight times from the start, N1 is sure to be not less than 7, and a set of processing in S10 and S11 is performed every time when reception is successful because N1 is surely not less than 7. A condition that processing is not performed after reception eight times, but performed every other time may be established.

[0118] In addition, the number of data stored in the reception information storage unit 71 may be obtained by storing every data successful in reception from the start point, and obtaining the average value, etc. of the time correction making use of the latest seven sets of data among every data, or only seven sets of data is consistently stored from the viewpoint of the storage capacity, and if new data is stored, the oldest data may be deleted. Thus, the average value of the time correction is the average value based on the time correction persistently when reception is successful, and does not include any estimated correction.

[0119] Changing of the reception schedule will be described with reference to the flowchart in Fig. 6.

[0120] In the reception schedule changing (S10), the reception schedule control unit 63 firstly calculates the average value of the time correction value as shown in Fig. 6 (S21). In addition, dispersion in the time correction value is calculated (S22). "Dispersion" in the time correction value means the degree of deviation of each time correction value from the regression equation of the time correction value, and can be expressed, for example, by the standard deviation, etc. at the deviation of each time correction value from the regression equation.

[0121] Next, the reception schedule control unit 63 determines whether or not the average value is equal to or less than a first set value A1 for the average value with the line of 0 second/day as a reference stored in the set value storage unit 73 (S23). The first set value

A1 for the average value is appropriately set in implementation, and, for example, set to be 0.25 second/day. In a case of the time correction value shown in Fig. 9(1), the average value of the time correction value for seven days with the reception and the correction for the first to seventh days is about 0.21 second/day, which is equal to or less than the first set value A1 for the average value, and determined to be Yes in S23, and the reception interval extension (S30) is executed. Thus, neither reception nor correction is performed on the eighth day.

[0122] Here, in a graph of Fig. 9, a "●" mark shows the correction by the comparison of the time of reception with the internal time in each day in which reception and correction are performed. The "x" mark shows that neither reception nor correction is performed. More specifically, this indicates the case in which the average value of the correction for the past seven days (the time correction value) is equal to or less than the first set value A1 for the average value. In Fig. 9(1), the "x" mark is located on the curve of 0.2 second/day, but this is indicated on a regression line 100 as described below for the convenience of graphical expression, and does not indicate any correction.

[0123] A "Δ" mark indicates the estimated correction corrected by the estimated correction without any reception. More specifically, this is a case in which the average value of the correction for the last seven days in which reception and correction are performed exceeds the first set value A1.

[0124] When determined No in S23, the reception schedule control unit 63 determines whether or not dispersion in the time correction value is equal to or less than the "first set value B1 for the dispersion" stored in the set value storage unit 73 (S24). Even when the average value of the correction (the time correction value) is larger than the first set value A1 for the average value, each time correction value indicates a substantially constant tendency if the dispersion is equal to or less than the first set value B1 for the dispersion, and if each time correction value is located substantially along the regression equation (the regression line, etc.), the time correction can be performed by the estimated correction described below without performing radio wave reception, and the radio wave reception interval can be prolonged.

[0125] Thus, for example, as shown in Fig. 9(2), if the regression line 100 of each time correction value is increased at a predetermined ratio, the average value of the time correction value is larger than the first set value A1 for the average value. However, each time correction value is within a range B around the regression line, and the dispersion is equal to or less than the first set value B1 for the dispersion, and the reception interval is extended (S30).

[0126] The range B shown in Figs. 9(1) and (2) indicates the range of the first set value for the dispersion. Here, the regression line 100 is substantially agreed with the scale mark of 0.2 second/day, and expressed

by a one-dot-chain line (alternate long and short dash line) in Fig. 9(2). In addition, the regression line 100 shown in Fig. 9(1) indicates the regression line at the time point of the sixteenth day, i.e., the regression line of each time correction value for seven days performing reception and correction of the fourth, fifth, sixth, seventh, ninth, twelfth, and sixteenth days. Similarly, the regression line 100 shown in Fig. 9(2) indicates the regression line of each time correction value for seven days performing reception and correction of the third to seventh, ninth, and twelfth days. The dispersion is expressed by the range around the regression line 100, and the range B indicates the range from (the regression line 100 + the first set value B1 for the dispersion) to (the regression line 100 - the first set value B1 for the dispersion).

[0127] For example, in Fig. 9(1), the lower limit of the range B is 0.1 second/day, the upper limit is 0.3 second/day, and the size of the range B is "0.3 - 0.1 = 0.2 second/day". And, the first set value B1 for the dispersion =  $B/2 = 0.1$  second/day.

[0128] On the other hand, if determination in S24 is No, the reception schedule control unit 63 determines whether or not the average value of the time correction value is not less than the second set value A2 for the average value with the line of 0 second/day as the reference (S25). This second set value for the average value may only be larger than the first set value A1 for the average value, and may be appropriately set in implementation. In the present embodiment, for example, in Fig. 9(1), the second set value A2 for the average value is set to be 0.30 second/day, etc.

[0129] If the average value of the time correction value is determined to be not less than the second set value A2 for the average value in S25, the reception schedule control unit 63 performs the shortening of the reception interval (S27). More specifically, the reception schedule control unit 63 selects reception schedule information E from the reception schedule storage unit 72 (S27), and subsequent reception is performed every half day. The variable N2 indicating the kind of schedule information when prolonging the reception interval is reset to the initial value "0" because the reception interval is shortened (S28).

[0130] If determination in S25 is No, in other words, if the correction is larger than the first set value A1 for the average value and equal to or less than the second set value A2 for the average value, the reception schedule control unit 63 determines whether or not the dispersion of the time correction value is not less than the second set value B2 for the dispersion (the range around the regression line 100 similar to the first set value B1 for the dispersion) (S26). Also when the dispersion is not less than the second set value B2, the shortening of the reception interval is performed (S27).

[0131] If determination in S26 is No, in other words, if the average value is between the first and second set values for the average value, and the dispersion is also

between the first and second values for the dispersion, the reception schedule control unit 63 performs the changing to schedule information A (once/day) of the initially set value (S29), and  $N2 = 0$  in the processing S28.

**[0132]** The second set value B2 for the dispersion may only be not less than the first set value B1 for the dispersion, and may be appropriately set, and for example, set to be 0.15 second/day, etc. If the second set value B2 for the dispersion is same as the first set value B1, and the dispersion of the time correction value exceeds, for example, the range B, the reception interval is immediately shortened. On the other hand, if the second set value B2 for the dispersion is larger than the first set value B1, the time correction value is only reset to the initial schedule information A even when the dispersion exceeds the range B, and only when the second set value B2 is exceeded, schedule information E is selected, and the reception interval is shortened.

**[0133]** For example, as shown on the sixteenth day in Fig. 9(1), if the average value of the time correction value exceeds the first set value A1 for the average value, the second set value A2 for the average value, and the range B, schedule information E is selected, the reception interval is shortened, and reception and time correction is performed on the 16.5-th day. Subsequently, reception and time correction is performed on the every 0.5 day. However, if the time correction for the last seven days is completely within the range B, the reception interval is prolonged, returning to the reception once in a day again.

**[0134]** Next, prolongation of the reception interval (S30) is described based on the flowchart in Fig. 7.

**[0135]** In prolongation (S30) of the reception interval, the reception schedule control unit 63 firstly determines whether or not  $N2$  is "0" (S31). When prolongation of the reception interval (S30) is performed, because of  $N2 = 0$ , reception schedule information B is selected (S32), and  $N2$  is updated to "1" (S33). Thus, the subsequent reception timing becomes once every two days. More specifically, the reception timing is set so as to perform reception in two days after the date of last reception.

**[0136]** In addition, if prolongation of the reception interval (S30) is performed while present reception schedule information B is selected, the reception schedule control unit 63 determines No in S31 because  $N2 = 1$ , and further determines whether or not  $N2 = 1$  (S34). Here, determination becomes Yes, reception schedule information C is selected (S35), and  $N2$  is updated to "2". Thus, the next reception timing becomes the same one after three days.

**[0137]** In addition, if prolongation of the reception interval (S30) is performed while present reception schedule information C is selected, the reception schedule control unit 63 determines No in S31 and S34, respectively, because  $N2 = 2$ , and reception schedule information D is selected (S37).  $N2$  is left unchanged from "2". Thus, the next reception timing becomes the same one

after four days.

**[0138]** In the present embodiment, only at most one schedule information D in four days is set. Thus, even of prolongation of the reception interval (S30) is performed while present reception schedule information D is selected, prolongation is performed with the unchanged reception schedule information D and S37 is processed. In prolongation of the reception interval, prolongation of the reception interval longer than schedule information D can be repeated. However, as illustrated in the present embodiment, the reception interval is preferably stopped to a predetermined value. For example, if radio wave reception is not performed for a period as long as one to six months, any correct time data cannot be obtained, leading to the possibility that correct time cannot be displayed.

**[0139]** As described above, when changing of the reception schedule (S10) is completed, time correction (S11) with the estimated correction is performed successively.

**[0140]** In this time correction, the correction calculation unit 62 determines whether or not  $N2$  is larger than 0 as shown in the flowchart of Fig. 8 (S41). Time correction with the estimated correction performs only time correction when the reception interval is prolonged from the initially set schedule of once in a day, and radio wave reception is skipped. Thus, time correction is performed only in cases of reception schedule information B to D, i.e.,  $N2 = 1, 2$ . Thus, if  $N2 = 0$ , time correction is completed without any operation.

**[0141]** On the other hand, if determination in S41 is Yes, the correction calculation unit 62 calculates the estimated correction at the scheduled date for skipping the next reception (S42). More specifically, the estimated correction may be calculated by substituting the skipping date in the above regression equation.

**[0142]** If the estimated correction is larger than the correction determination value, the correction calculation unit 62 performs time correction with the estimated correction at the skipped reception schedule time (S44).

**[0143]** On the other hand, if the estimated correction is equal to or less than the determination value, indication error is estimated to be smaller even when no time correction is performed, and the reception schedule control unit 63 and the correction calculation unit 62 perform neither radio wave reception nor time correction (S45).

**[0144]** The correction calculation unit 62 determines whether or not the next reception timing is reached (S46), and if the reception timing is not reached, the above steps S42 to S45 are repeated. In other words, if reception schedule information C and D is selected, the reception date is skipped two or three times before the next reception. Thus, the correction calculation unit 62 calculates the estimated correction in each skip, and appropriately performs time correction based on the value.

**[0145]** On the other hand, when it is determined in S46 that the reception timing is reached, the correction

calculation unit 62 completes time correction S11, and processing is repeated from S3A.

[0146] According to the present embodiment, the following advantages can be obtained.

(1) In the present embodiment, if radio wave reception cannot be performed, correct data cannot be received due to the influence of noise, etc., or correct time information cannot be acquired, the correction calculation unit 62 calculates the estimated correction, and corrects the internal time using the estimated correction, and even when time correction by external radio information cannot be performed, indication error of time can be suppressed small, realizing an electronic equipment with high time indication accuracy.

In addition, even when the radio wave reception interval is increased by the change of the reception schedule, time correction can be appropriately performed by using the estimated correction, and indication error can be reduced. Thus, the less easily compatible technical advantages of reduction of power consumption and improvement of time indication accuracy can be simultaneously achieved.

(2) In addition, the correction calculation unit 62 performs time correction only when the estimated correction is not less than the determination value, but it does not perform time correction if the estimated correction is equal to or less than the determination value, and power consumption can be reliably reduced more than a case when time correction is performed.

(3) The reception schedule control unit 63 changes and controls the subsequent reception schedule based on reception timing data and difference data obtained through a plurality of sets of reception, and compared with a case in which the reception interval is changed only in once reception, the schedule can be set based on more correct reception information, the possibility of error occurrence can be reduced, and the deviation in time data output in the display unit 28, etc., i.e., indication error can be minimized.

In addition, the reception interval can be increased by changing the reception schedule, and power consumption can be reduced. Thus, when a portable electronic equipment, like a wristwatch, is driven by a battery, the service life of the battery can be prolonged. Accordingly, the duration can be increased from the conventional value for the electronic equipment having a process of reception operation consuming much power.

(4) In addition, in the present embodiment, the reception schedule control unit 63 successively selects initial reception schedule information A once in a day, reception schedule information B once in two days, reception schedule information C once in three days, and reception schedule information D

once in four days so as to gradually prolong the reception interval, and power consumption can be further suppressed. In addition, prolongation of these reception intervals is performed when the average value of the time correction value is equal to or less than the first set value for the average value, the dispersion in the time correction value is equal to or less than the first set value for the dispersion, and fluctuation is small, and little error occurs in time indication even when the radio wave reception interval is prolonged.

(5) Still further, when changing the reception schedule, determination is performed not only by the average value of the time correction value but also by the dispersion in the time correction value, and the reception interval can be prolonged more often compared with a case in which determination is performed only by the average value of the time correction value, and power consumption can be reduced more. In other words, when determination is performed only by the average value of the time correction value, the radio wave reception interval cannot be prolonged if the average value is higher than the first set value. On the other hand, if the dispersion is smaller though the average value of the time correction value is higher, the radio wave reception interval is prolonged, and power consumption of the radio wave correction timepiece 1 can be further reduced.

(6) In addition, the reception schedule control unit 63 not only prolongs the reception interval but also shortens the reception interval when the dispersion in the time correction value is larger than the second set value for the dispersion, or when the average value of the time correction value is larger than the second set value for the average value, and optimum radio wave reception control for the situation can be performed, time correction by radio wave reception can be reliably performed, and time indication accuracy can be improved thereby.

(7) Since the forced reception can be performed by providing the external operation unit 29, users can perform radio wave reception at free timing by the reception schedule control unit 63 even when the reception schedule interval is prolonged, and even when error occurs in time indication by prolongation of the reception interval, the error can be corrected immediately if users perform the forced reception as necessary, and no problems occur in practical applications.

(8) Since the reception schedule storage unit 72 and the set value storage unit 73 are provided, each reception schedule information, each set value, and each determination value can be easily changed or added. Thus, such information can be easily set by users according to each model and service conditions, or when the product is shipped from the factory.

## [Second Embodiment]

[0147] The second embodiment of the present invention will be described with reference to Figs. 10 to 12. The components in the present embodiment which are identical to or correspond to those in the first embodiment are represented by the same reference numerals, and a detailed description thereof is omitted.

[0148] The radio wave correction timepiece 1 according to the second embodiment is different from that in the first embodiment only in that the magnetic field detection unit 81 and the reception processing control unit 82 are added as shown in Fig. 10, and other configuration is the same as that of the first embodiment.

[0149] The magnetic field detection unit 81 detects electromagnetic noise by using the antenna 21, the reception circuit 22, etc. The electromagnetic noise includes those generated by the external magnetic field applied from external appliances such as AC magnetic field and high frequency magnetic field, and the internal magnetic field due to the operation of a generator disposed inside the appliances.

[0150] The magnetic field detection unit is not limited to one comprising the antenna 21 and the reception circuit 22, but any magnetic field detection unit capable of detecting electromagnetic noise may be acceptable. For example, a magnetic field detection unit may be acceptable in which a drive coil of a stepping motor in the display unit 28 is used as the antenna, and its drive circuit is utilized for a magnetic field detection circuit. Alternatively, when an AC generator is built in, the magnetic field can be detected by the magnetic field detection circuit by using its power generation coil as the antenna, or electromagnetic noise may be detected by using a power generation detection circuit for detecting a power generation state from the generated power induced in the power generation coil, etc.

[0151] The reception processing control unit 82 controls so as not to reject reception even if the timing of performing radio wave reception is reached on the schedule in the reception schedule control unit 63 when detecting electromagnetic noise of the predetermined intensity by the magnetic field detection unit 81.

[0152] Control is performed as shown in Figs. 11 and 12 in the second embodiment.

[0153] This means, as shown in Fig. 11, when it is determined by the reception schedule control unit 63 that the forced reception is present (S3A) or the reception timing is reached (S3B), reception (S4) is not performed immediately, but presence/absence of detection of the magnetic field by the magnetic field detection unit 81 is determined by the reception processing control unit 82, and notified to the reception schedule control unit 63 (S51). If any magnetic field is not detected here, the reception schedule control unit 63 performs the same processing as that of the first embodiment after reception (S4).

[0154] On the other hand, if any magnetic field is de-

tected in S51, the reception schedule control unit 63 determines whether or not reception has been already performed seven times (S52). If the number of reception is below seven, the calculation accuracy of the estimated correction is degraded, the processing is returned to the determination of the next reception timing without any operation (S3).

[0155] If it is determined that reception has been performed at least seven times in S52, the information is notified from the reception schedule control unit 63 to the correction calculation unit 62, and the correction calculation unit 62 performs time correction (S53) with the estimated processing quantity.

[0156] Because time correction according to the present embodiment is performed if electromagnetic noise is detected at the time when radio wave reception is performed, the processing flow according to the second embodiment is different from the processing flow in Fig. 8 in that checking of reception schedule information in S41 and determination of the next reception timing in S46 are omitted, and there is no difference in other processing. Accordingly, the description thereof will be omitted.

[0157] This embodiment includes not only every advantage of the first embodiment but also advantages described below.

(9) Since the magnetic field detection unit 81 and the reception processing control unit 82 are provided, execution of radio wave reception can be stopped if electromagnetic noise affects during radio wave reception. Thus, any standard wave is prevented from being mistakenly received, or corrected at incorrect time due to the effect of electromagnetic noise, and time accuracy can be improved more because time correction can be performed by the radio wave information only when correct radio wave is received.

(10) In addition, even when radio wave cannot be received due to electromagnetic noise, time correction is performed by the estimated correction, and generation of indication error can be suppressed. In particular, if radio wave reception cannot be performed due to electromagnetic noise, radio wave reception must generally be performed again after one hour, etc. However, in the present embodiment, time correction is performed by the estimated correction, and radio wave reception need not be performed again, and power consumption can also be reduced more, accordingly.

## [Third Embodiment]

[0158] The third embodiment of the present invention will be described with reference to Figs. 13 and 14. The components in the present embodiment which are identical to or correspond to those in the first and second embodiments are represented by the same reference

numerals, and a description thereof is omitted.

[0159] The radio wave correction timepiece 1 according to the third embodiment has the configuration of the first embodiment as shown in Fig. 13, but is different in that information on unsuccessful radio wave reception is notified from the comparison circuit 54 to the correction calculation unit 62 when radio wave reception is unsuccessful if users of the radio wave correction timepiece 1 are inside a building or a subway, or due to troubles on a transmitter side, natural phenomena such as magnetic storm, etc., and other configuration is identical to that of the first embodiment.

[0160] In other words, the comparison circuit 54 determines whether or not correct time information is received, and notifies the determination information to the correction calculation unit 62.

[0161] In the third embodiment, control is performed as shown in Fig. 14. As shown in Fig. 14, reception (S4) is performed when the reception schedule control unit 63 determines that the forced reception (S3A) is performed, or the reception timing is reached (S3B).

[0162] Then, the comparison circuit 54 determines whether or not reception is successful (S5). If successful reception is determined, the same processing as the processing in the first embodiment is performed subsequently.

[0163] On the other hand, if it is determined that reception is unsuccessful in S5, the correction calculation unit 62 determines whether or not reception has already been performed seven times (S52). If the number of reception is below seven, the calculation accuracy of the estimated correction is degraded, processing is returned to determination of presence/absence of the forced reception without any operation (S3A).

[0164] If it is determined that reception has been performed at least seven times in S52, the correction calculation unit 62 performs time correction (S53) with the estimated processing quantity.

[0165] Time correction according to the present embodiment is the same as that in the processing flow in Fig. 12 of the second embodiment, and a description thereof will be omitted.

[0166] This embodiment includes not only every advantage of the first embodiment but also advantages described below.

(11) If it is determined that reception is unsuccessful in the comparison circuit 54, information is notified to the correction calculation unit 62. Since time correction with the estimated correction is performed by the correction calculation unit 62, generation of indication error can be suppressed. Thus, for example, even when the radio wave could be received though correct time information could not be acquired because the radio wave was affected by the electromagnetic noise of external magnetic field, etc., or even when the standard wave could be received and correct time information could not be ac-

quired because users were inside a building or a subway, time correction can be performed by using the estimated correction, and time indication is not deviated largely, and substantially correct time can be indicated consistently irrespective of external circumstances.

[0167] In addition, similar to the second embodiment, when radio wave reception cannot be performed, radio wave reception need not be performed again, and power consumption can also be further reduced, accordingly.

[0168] The present invention is not limited to only each of the above embodiments, but may of course be modified in a various manner so long as not to be deviated from the scope of the present invention.

[0169] For example, in the flowchart in Fig. 5 of the first embodiment, if radio wave reception is unsuccessful in S5, the control is performed so as to wait for the next reception timing. However, similar to the third embodiment, even when radio wave reception is unsuccessful in S5, time correction may be performed with the estimated correction. In this method, if a user is within a place difficult for radio wave reception such as a building, a subway, and an underground passage by accident at the reception timing, and cannot receive the radio wave, time correction can be performed with the estimated correction and large time deviation can be prevented.

[0170] And, in the embodiment, as shown in the flowchart in Fig. 6, if the average value of the time correction value is equal to or less than the first set value for the average value, or if the dispersion in the time correction value is equal to or less than the first set value for the dispersion, the reception schedule is changed so that the reception interval is longer than the initially set value. However, only when the average value of the time correction value is equal to or less than the first set value for the average value, and the dispersion in the time correction value is equal to or less than the first set value for the dispersion, the reception schedule may be changed so that the reception interval is longer than the initially set value. In this method, only when both conditions are satisfied, the reception interval is prolonged, and only when the time correction value is small in fluctuation, and stable, the reception interval is prolonged, and the time indication error can be more reliably reduced.

[0171] Further, in the embodiment, as shown in the flowchart in Fig. 6, if the average value of the time correction value is not less than the second set value for the average value, or if the dispersion in the time correction value is not less than the second set value for the dispersion, the reception schedule is changed so that the reception interval is shorter than the initially set value. However, only when the average value of the time correction value is not less than the second set value for the average value, and the dispersion in the time cor-



reception value is not less than the second set value for the dispersion, the reception schedule may be changed so that the reception interval is shorter than the initially set value. In this method, only when both conditions are satisfied, the reception interval is shortened, priority can be given to suppression of the increase in power consumption required by reception compared with the increase in the time accuracy by shortening the reception interval, and this method is effective when providing the power-saving mode, etc.

**[0172]** In the second embodiment, control is performed to prohibit reception if electromagnetic noise is detected. However, control may be performed so as not to perform time correction based on the data by invalidating the received data while performing reception itself in order to grasp the reception situation.

**[0173]** In the second and third embodiments, when no reception is performed or the radio wave cannot be received due to detection of electromagnetic noise, only the time correction is performed, and the radio wave reception is performed at the next reception timing. However, radio wave reception may be controlled to be performed again after the set time (for example, after one hour). In particular, when the present reception schedule information has a short reception interval like the information E, and radio wave reception is performed if possible, such control is effective. On the other hand, if the reception schedule information has the reception interval set to be originally long like the information B to D, no serious problem occurs even when the radio wave reception schedule is skipped once, and thus, control in the second embodiment is suitable.

**[0174]** If electromagnetic noise is also detected in the next reception, processing may be performed again after the set time.

**[0175]** In each of the above embodiments, the reception data for seven times in the past need not be continuous, the control is performed based on the simply received data for seven times in the past, but the control may be performed based on the continuously received data according to the reception schedule.

**[0176]** In addition, in the embodiment, the schedule change is performed after receiving the radio wave seven times. However, as shown in Fig. 15(3), the schedule change may be performed by receiving the radio wave only three times. In short, reception timing data and difference data obtained by receiving the radio wave at least a plurality of times can be utilized.

**[0177]** In addition, the data number for obtaining the average value, etc. of the time correction value may be changed by the time correction value, etc. For example, as shown in Fig. 15(3), if the time correction value is stable at 0.1 second/day, measuring of the time is also considered to be stable, and information necessary for controlling the change of the reception schedule can be obtained even with the number as small as three. Therefore, if the time correction value is the same, the schedule change, etc. is performed in three times, and if the

time correction value is not stable, the schedule change, etc. may be performed with more data in, for example, seven times.

**[0178]** In the above embodiment, the reception interval is changed by the average value and the dispersion of the time correction value. However, for example, as shown in Fig. 15(3), the reception interval may be changed according to whether or not the time correction value exceeds an allowable range ( $A = 0.2$  second/day). In addition, as shown in Fig. 15(4), two allowable ranges A1 and A2 with 0 second/day as the reference line are set. The reception interval is shortened every half day, if the time correction value exceeds the range A2, and prolonged every day if the time correction value is then returned to A1 or under.

**[0179]** In an example in Fig. 15(4), the time correction value on the sixth day remains within a range B in terms of the dispersion. However, the value exceeds the range A2, and the reception interval is shortened to be one half day.

**[0180]** Also in this case, it may also be determined whether or not the dispersion in the time correction value remains within the set value, for example, each time correction value is within the allowable range B (for example, 0.15 second/day). In addition, the reception interval may be changed only with this dispersion.

**[0181]** Further, in the above embodiment, both the average value and the dispersion of the time correction value are used. However, determination may be performed with only the average value or the dispersion.

**[0182]** In addition, each set value and each determination value may be set on the positive side or the negative side, or on both sides with 0 second/day as the reference, and may be appropriately set.

**[0183]** In addition, each set value and each determination value may be expanded or contracted in response to the elapse of time.

**[0184]** In addition, each set value and each determination value may be changed taking into consideration the seasonal fluctuation or the like. In particular, a quartz oscillator, etc. has its temperature characteristic in a strict sense, and if the outside temperature is different such as between the summer and the winter, the measuring accuracy is also different slightly. Therefore, the time correction value can be different in tendency according to the season, and control can be performed with higher accuracy if each set value and each determination value are set taking into consideration these factors.

**[0185]** Each set value and each determination value described above may be freely set when shipped from the factory or by a user, or changed from the preset options by operating a setting changing unit such as a winding crown and a button.

**[0186]** In addition, each set value and each determination value, together with various kinds of control programs may be installed or changed by the radio communication via the antenna 21 or the network commu-



nication via cables.

**[0187]** In each of the above embodiments, both the change of the reception schedule and the time correction with the estimated correction are performed. However, only the change of the reception schedule may be performed. If the time correction is also performed at the same time, the time indication error is reduced even when the reception interval is prolonged to be every three days or every four days, with the result that the reception interval can be expanded, and the power consumption can be considerably reduced to 1/3 to 1/4 of the conventional value.

**[0188]** In addition, the reception schedule information is not limited to the information A to E described above, but may be one with longer reception interval (once/five days, once/10 days, etc.), or may be another with shorter reception interval (four time/day, etc.)

**[0189]** In the above embodiment, the schedule information A to D is gradually selected in the order of information A, B, C, and D. However, each schedule information A to E may be selected directly according to, for example, the average value of the time correction value. For example, if the schedule information A is selected, and the average value of the time correction value is very small, the schedule information D may be selected directly next.

**[0190]** In addition, in each of the above embodiments, the reception schedule storage unit 72 is provided. However, the reception schedule may be calculated and set directly in the reception schedule control unit 63 without providing the reception schedule storage unit 72. For example, the reception schedule may be set by the average value by providing a routine program capable of calculating the reception interval with the average value of the time correction value as a parameter.

**[0191]** Regarding the prediction of the estimated correction from the data on the time of reception correction in the past, it is acceptable if the estimated correction can be predicted, and other embodiments than the above ones are included in the present invention.

**[0192]** For example, in each of the above embodiments, the estimated correction is updated by successively utilizing the newly received data. However, as shown in Fig. 16, the data in one week (from Monday to Sunday) is received for the data in the past, the estimated correction for each day of the subsequent week may be calculated and corrected according to the data change in one week. More specifically, the data for one week is first accumulated, and then, the estimated correction may be used for each day of the week by utilizing the data for each day of the week for the data. In such cases, as shown in Fig. 16, each time correction must be present within the allowable range C set for the curve of the average value.

**[0193]** Regarding data acquisition, the data for one week may be acquired every one to several months. Alternatively, a manual data acquisition mode may be provided in which a user acquires the data for one week

after the data acquisition instruction is given by the user.

**[0194]** In addition, the estimated correction for each day of the week may be calculated by accumulating the data for one to several weeks, not limited to the data for one week, and using the data for each day of the week.

**[0195]** In such cases, for example, when there is an influential difference in life cycle between the week days at work or in school and the holidays, the estimated correction can be performed taking into consideration the influence for each day of the week, and time correction with high accuracy can be performed when the life cycle is largely influential. In addition, for the data in the past, not limited to the data for one week, but the data for one year may be accumulated as shown in Fig. 17, the monthly correction is calculated to grasp the tendency in the data change, and the estimated correction is calculated and corrected from the next year based on the monthly correction of the data in the past before the previous year. In particular, if there are temperature changes according to the seasons as in Japan, the correction is also increased/decreased according to the temperature changes, and time correction with high accuracy can be performed by calculating the estimated correction according to each month.

**[0196]** The radio wave correction timepiece 1 may be provided with an indicating means for indicating the present reception schedule information and the number of elapsed days from the date of the last reception of the radio wave, etc., so that a user can easily grasp the present condition. Regarding this indicating means, the mode is switched to the schedule indication mode by using, for example, a winding crown and a button, indicating the scale on a dial plate by a second hand by 10 seconds through the instruction as the information A to E, or by providing a liquid crystal screen on the dial plate.

**[0197]** In addition, whether the present time indicates the time corrected by the received radio wave, or the time corrected by the estimated correction, i.e., the kind of the time may be indicated by an indicating means of the liquid crystal screen, an organic EL screen, etc. This indication timing may be constantly made, or only for a predetermined time when a winding crown and a button is operated. In addition, the information on the kind of the time is not limited to the screen indication, but may be indicated by a special operation of the indicator for indicating the time, or an exclusive indication pointer hand.

**[0198]** Each means in the control circuit 24 may be constituted by the hardware such as various kinds of logical elements, or comprise a computer having a CPU (a central processing unit), and a memory (a storage device) disposed in the timepiece 1, with predetermined programs and data (the data stored in each storage unit) installed in the computer to realize each means.

**[0199]** For example, a CPU and a memory are disposed in the radio wave correction timepiece 1 so as to be functioned as the computer, the predetermined control programs and data are installed in this memory via

communicating means such as Internet, and recording media such as CD-ROMs and memory cards, the CPU, etc. is operated by these installed programs to realize each means.

**[0200]** When the predetermined programs, etc. are installed in the radio wave correction timepiece 1, the memory cards, CD-ROMs, etc. may be inserted directly in the radio wave correction timepiece 1, or an appliance capable of reading these recording media may be externally connected to the radio wave correction timepiece 1. In addition, programs, etc. may be supplied through the communication by connecting LAN cables, telephone lines, etc. to the radio wave correction timepiece 1, and installed therein, or the programs may be supplied through radio using the antenna 21 provided thereon, and installed therein.

**[0201]** If the control programs, etc. provided using such recording media and communicating means such as Internet are installed in the radio wave correction timepiece 1, the function of each invention can be realized only by changing the programs, and the control programs can be installed when shipped from the factory, or the control programs desired by users can be selected and installed. In such cases, various kinds of radio wave correction timepieces 1 of different control mode can be manufactured only by changing the programs, parts can be commonly used, and the manufacturing cost when developing variation can be considerably reduced.

**[0202]** The function as the radio wave correction timepiece, i.e., each configuration of a measuring means, a receiving means, a time correcting means, etc. is not limited to that of the above embodiments, but each means of the radio wave correction timepiece which has been known can be used.

**[0203]** The radio wave correction timepiece 1 of the present invention is not limited to an analog type timepiece, but may be a digital type timepiece or a timepiece having both an indicator for analog display and a liquid crystal display unit for digital display. In addition, the radio wave correction timepiece 1 is applicable of various kinds of timepieces including portable timepieces such as a wristwatch and a watch, and installation type timepieces such as a wall timepiece and a timepiece to stand on a table.

**[0204]** In addition, external radio information is not limited to time information by the standard long wave. For example, it may be radio information by FM, GPS, Bluetooth, and noncontact IC card so long as it includes at least time information. It goes without saying that the configuration, etc. of the antenna 21 and the reception circuit 22 is appropriately changed according to the kind of the radio wave.

**[0205]** In addition, the electronic equipment of the present invention is not limited to that according to the above embodiments, but may be a master-slave timepiece or a repeater. Here, the master-slave timepiece means a timepiece in which time information of a parent

timepiece is transmitted to a child timepiece by radio, etc., and the child timepiece performs time correction based on the time information. Thus, the parent timepiece comprising a wall timepiece and a timepiece to stand on a table is constituted of the electronic equipment of the present invention, the signal of the estimated correction calculated by the correction calculation unit of the parent timepiece is transmitted to the child timepiece, and the child timepiece (a wristwatch, a timepiece to stand on a table, etc.) may perform time correction by the estimated correction.

**[0206]** Alternatively, the parent timepiece transmits to the child timepiece the correction (difference between internal and external time data) when receiving external radio information such as radio wave at the predetermined reception interval by the reception schedule control unit, and the child timepiece may perform time correction based on the correction.

**[0207]** Similarly, the present invention may be applied to the repeater which receives external radio information and transfers it to timepiece devices, etc., and similar to the above parent timepiece, the estimated correction signal and the signal of the correction by the radio wave received at the predetermined reception interval are transmitted to a measuring device, and the measuring device receives the information, and performs time correction to indicate correct time.

**[0208]** In addition, the electronic equipment of the present invention is not limited to a radio wave correction timepiece, but any timepiece such as a personal computer, an electronic toy, and a timer which performs any processing or operation by utilizing correct time information. In particular, the present invention is effective in reducing power consumption, and suitable for a battery-driven portable electronic equipment. In this occasion, the electronic equipment is not limited to ones using a regular primary battery, but may be ones having various kinds of generators such as a solar battery. This type of electronic equipment is also advantageous in that the power consumption can be reduced, and the duration can be prolonged.

#### [Other Embodiments of the present invention]

**[0209]** Other embodiments of the present invention will be described below.

**[0210]** A reception control method of the electronic equipment according to a first embodiment is a reception control method of the electronic equipment having an external radio information reception unit for receiving external radio information including time information and an internal time measuring unit for measuring the internal time based on the reference clock, and comprises a time data comparison step of comparing external time data forming time information received by the external radio information reception unit with internal time data measured by the internal time measuring unit, and outputting the difference therebetween, a reception in-

formation storage step of storing at least a plurality of sets of each data on the timing of receiving the external radio information by the external radio information reception unit and the difference thereof, a correction calculation step of calculating the estimated correction by the plurality of sets of reception timing data, difference data, and the elapsed time from the last reception, and an internal time correction control step of correcting the internal time by using the estimated correction.

[0211] A second embodiment further comprises a schedule control step of controlling the reception schedule in the external radio information reception unit in the first embodiment, and the internal time correction control step is characterized in that the internal time is corrected by using the estimated correction if time information is unsuccessfully acquired when external radio information is received based on the reception schedule.

[0212] A third embodiment further comprises a schedule control step of controlling the reception schedule in the external radio information reception unit according to the first or second embodiment, and the internal time correction control step is characterized in that the internal time is corrected by using the estimated correction if no reception is performed though at the reception timing with the reception schedule of the initially set value because the reception schedule is changed by the reception schedule control step.

[0213] A fourth embodiment further comprises an external operation unit of instructing the forced reception of external radio information by the external radio information reception unit according to any one of the first to third embodiments, and the internal time correction control step is characterized in that the internal time is corrected by using the estimated correction if time information by receiving the external radio information is unsuccessfully acquired when the forced reception is instructed by operating the external operation unit by a user.

[0214] A fifth embodiment further comprises a magnetic field detection unit for detecting electromagnetic noise according to any one of the first to third embodiments, and is characterized in that a reception processing control step of prohibiting reception operation or invalidating reception data by the external radio information reception unit when detecting electromagnetic noise by the magnetic field detection unit is provided.

[0215] A sixth embodiment further comprises a reception schedule control step of controlling the reception schedule in the external radio information reception unit according to the fifth embodiment, and the internal time correction control step is characterized in that the internal time is corrected by using the estimated correction if electromagnetic noise is detected by the magnetic field detection unit, and reception operation is prohibited or the reception data is invalidated, and time information is unsuccessfully acquired in the reception control step when receiving external radio information based on the reception schedule.

[0216] A seventh embodiment comprises an external

operation unit for instructing the forced reception of external radio information by the external radio information reception unit according to the fifth or sixth embodiment, and the internal time correction control step is characterized in that the internal time is corrected by using the estimated correction if electromagnetic noise is detected by the magnetic field detection unit, and reception operation is prohibited or reception data is invalidated in the reception control step, and time information is unsuccessfully acquired in case the forced reception is instructed by operating the external operation unit by a user.

[0217] An eighth embodiment is a reception control method of an electronic equipment having an external radio information reception unit for receiving external radio information including time information, and an internal time measuring unit for measuring the internal time based on the reference clock, and comprises a time data comparison step of comparing external time data forming time information received by the external radio information reception unit with internal time data measured by the internal time measuring unit to output the difference therebetween, a reception information storage step of storing at least a plurality of sets of each data on the timing of receiving the external radio information by the external radio information reception unit and the difference thereof, and a schedule control step of controlling the reception schedule by the external radio information reception unit based on the plurality of sets of reception timing data and the difference data stored in the reception information storage unit.

[0218] A ninth embodiment is characterized in that, according to any one of the second, third, sixth, and eighth embodiments, the reception schedule installation step changes the reception schedule so that the reception interval is longer than the initially set value when the average value of the time correction value per unit time, obtained by the reception timing and the difference thereof, is small and equal to or less than the first set value for the average value, and/or when the dispersion in the time correction value is small and equal to or less than the first set value for the dispersion.

[0219] A tenth embodiment is characterized in that, according to the ninth embodiment, the reception schedule control step changes the reception schedule so that the reception interval is longer than the initially set value by skipping the reception timing in the initially set reception schedule for at least once.

[0220] An eleventh embodiment is characterized in that, according to any one of the second, third, sixth, eighth, ninth, and tenth embodiments, the reception schedule control step changes the reception schedule so that the reception interval is shorter than the initially set value if the average value of the time correction per unit time, obtained by the reception timing and the difference thereof, is large and equal to or greater than the second set value for the average value, and/or if the dispersion in the time correction for each reception timing

is large and equal to or greater than the second set value for the dispersion.

[0221] The twelfth embodiment comprises a reception schedule storage unit storing a plurality of sets of reception schedule information in the external radio information reception unit according to any one of the second, third, sixth, eighth, ninth, tenth, and eleventh embodiments, and is characterized in that the reception schedule control step controls the reception schedule by selecting reception schedule information of the reception schedule storage unit of the reception schedule.

[0222] A thirteenth embodiment is characterized in that, according to any one of the first to seventh embodiments, the internal time correction control step corrects the internal time by using the estimated correction if the estimated correction calculated by the correction calculation unit is large and equal to or greater than the correction determination value.

[0223] A fourteenth embodiment is characterized in that, according to any one of the first to thirteenth embodiments, a plurality of sets of reception timing data and difference data stored in the reception information storage step is the data of the latest predetermined number out of a plurality of sets of data received in the past.

[0224] A fifteenth embodiment comprises a setting changing step according to any one of the first to fourteenth embodiments and is characterized in that setting of at least one of each set value and each determination value is changed.

[0225] A sixteenth embodiment is characterized in that, according to any one of the first to fifteenth embodiments, the electronic equipment is a radio wave correction timepiece having a display step of displaying the internal time measured by the internal time measuring unit.

[0226] A reception control program of an electronic equipment according to a seventeenth embodiment is characterized in that a computer built in the electronic equipment having an external radio information reception unit for receiving external radio information including time information and an internal time measuring unit for measuring the internal time based on the reference clock is functioned as a time data comparison unit for comparing external time data forming time information received by the external radio information reception unit with internal time data measured by the internal time measuring unit, and outputting the difference thereof, a reception information storage unit storing at least a plurality of sets of each data on the timing of receiving the external radio information by the external radio information reception unit and the difference thereof, a correction calculation unit for calculating the estimated correction by the plurality of sets of reception timing data, difference data, and the elapsed time from the last reception, and an internal time correction control unit for correcting the internal time by using the estimated correction.

[0227] A reception control program of an electronic equipment according to an eighteenth embodiment is characterized in that a computer built in the electronic equipment having an external radio information reception unit for receiving external radio information including time information and an internal time measuring unit for measuring the internal time based on the reference clock is functioned as a time data comparison unit for comparing external time data forming time information received by the external radio information reception unit with internal time data measured by the internal time measuring unit, and outputting the difference thereof, a reception information storage unit storing at least a plurality of sets of each data on the timing of receiving the external radio information by the external radio information reception unit and the difference thereof, and a reception schedule control unit for controlling the reception schedule in the external radio information reception unit based on a plurality of sets of reception timing data and difference data stored in the reception information storage unit.

[0228] A reception control program of an electronic equipment according to another embodiment of the present invention is a program for executing the reception control method according to the first to sixteenth embodiments by a computer built in the electronic equipment having an external radio information reception unit for receiving external radio information including time information, and an internal time measuring unit for measuring the internal time based on the reference clock.

[0229] In addition, a computer-readable recording medium according to another embodiment is a computer-readable recording medium recording a program for executing the reception control method according to the first to sixteenth embodiments in a computer built in the electronic equipment having an external radio information reception unit for receiving external radio information including time information and an internal time measuring unit for measuring the internal time based on the reference clock.

[0230] Similar operational advantages to those of the electronic equipment can also be obtained by these methods, programs, and recording media.

[0231] In addition, in this invention, the set value and the determination value can be easily changed when the computer is operated by the program. This means, if programs are provided, they can be installed in the electronic equipment via the recording media such as CD-ROMs and communicating means such as Internet, and the detection level of the external magnetic field can be optimally and easily set according to the characteristic of each electronic equipment, and reception control of higher accuracy can be performed.

[Advantages]

[0232] As described above, the electronic equipment

and the reception control method of the electronic equipment of the present invention, time correction can be performed by the estimated correction when electromagnetic noise is detected, or unsuccessful radio wave reception is detected, and a first advantage can be obtained in that substantially correct time data can be output even if correct time information cannot be acquired.

[0233] In addition, a second advantage can be obtained in that correct time data can be output while reducing the power consumption required for the reception if provided with a reception schedule control unit for controlling the reception schedule based on reception timing data and difference data.

[0234] Still in addition to the second advantage, a third advantage can be obtained in that the power consumption required for the reception can be reduced, and correct time data can be output even when correction is increased if provided with a correction calculation unit by the estimated correction.

## Claims

### 1. An electronic equipment comprising:

an external radio information reception unit for receiving external radio information including time information;

an internal time measuring unit for measuring the internal time based on the reference clock; a time data comparison unit for comparing external time data forming time information received by said external radio information reception unit with internal time data measured by said internal time measuring unit to output the difference therebetween;

a storage unit; and

a reception control unit,

wherein said storage unit comprises,

a reception information storage unit storing at least a plurality of sets of each data on the timing of receiving the external radio information by said external radio information reception unit and said difference thereof, and

wherein said reception control unit controls reception processing or internal time correction processing based on said plurality of sets of reception timing data and difference data.

### 2. An electronic equipment according to Claim 1, said reception control unit comprising:

a correction calculation unit for calculating an estimated correction by said plurality of sets of reception timing data, difference data, and the

elapsed time from the last reception; and an internal time correction control unit for correcting the internal time by using said estimated correction.

### 3. An electronic equipment according to Claim 2, wherein said reception control unit has a reception schedule control unit for controlling a reception schedule in said external radio information reception unit, and

wherein said internal time correction control unit corrects the internal time by using said estimated correction when time information is unsuccessfully acquired in case external radio information is received based on the reception schedule.

### 4. An electronic equipment according to Claim 2 or Claim 3,

wherein said reception control unit has a reception schedule control unit for controlling the reception schedule in said external radio information reception unit, and

wherein said internal time correction control unit corrects the internal time by using said estimated correction when reception is not performed at the reception timing on the initially set reception schedule because the reception schedule is changed by said reception schedule control unit.

### 5. An electronic equipment according to any one of Claims 2 to 4, having an external operation unit for instructing the forced reception of external radio information by said external radio information reception unit,

wherein said internal time correction control unit corrects the internal time by using said estimated correction when time information by receiving the external radio information is unsuccessfully acquired in case the forced reception is instructed by operating said external operation unit by a user.

### 6. An electronic equipment according to any one of Claims 2 to 4, having a magnetic field detection unit for detecting electromagnetic noise,

wherein said reception control unit has a reception processing control unit for prohibiting reception operation or invalidating reception data by an external radio information reception unit when detecting electromagnetic noise by said magnetic field detection unit.

### 7. An electronic equipment according to Claim 6,

wherein said reception control unit has a reception schedule control unit for controlling a reception schedule in said external radio information reception unit, and

wherein, in case external radio information is received based on said reception schedule, said in-

ternal time correction control unit corrects the internal time by using said estimated correction in case electromagnetic noise is detected by said magnetic field detection unit, and reception operation is prohibited or reception data is invalidated by said reception processing control unit when time information is unsuccessfully acquired.

8. An electronic equipment according to Claim 6 or Claim 7, having an external operation unit for instructing the forced reception of external radio information by said external radio information reception unit,

wherein, in case the forced reception is instructed by operating said external operation unit by a user, said internal time correction control unit corrects the internal time by using said estimated correction when electromagnetic noise is detected by said magnetic field detection unit, and reception operation is prohibited or reception data is invalidated by said reception processing control unit when time information is unsuccessfully acquired.

9. An electronic equipment according to Claim 1, said reception control unit comprising:

a reception schedule control unit for controlling the reception schedule in said external radio information reception unit based on said plurality of sets of reception timing data and difference data stored in said reception information storage unit.

10. An electronic equipment according to any one of Claims 3, 4, 7, and 9,

wherein said reception schedule control unit changes a reception schedule so that said reception interval is longer than the initially set value when an average value of a time correction value per unit time, obtained by said reception timing and difference thereof, is small and equal to or less than a first set value for the average value, and/or when the dispersion in said time correction value is small and equal to or less than the first set value for the dispersion.

11. An electronic equipment according to Claim 10, wherein said reception schedule control unit changes a reception schedule so that said reception interval is longer than the initial set value by skipping a reception timing in the initially set reception schedule for at least once.

12. An electronic equipment according to any one of Claims 3, 4, 7, 9, 10, and 11,

wherein said reception schedule control unit changes a reception schedule so that said reception interval is shorter than the initial set value in

case the average value of the time correction value per unit time, obtained with said reception timing and the difference thereof, is large and equal to or greater than the second set value for the average value, and/or in case the dispersion in the time correction value for each reception timing is large and equal to or greater than the second set value for the dispersion.

13. An electronic equipment according to any one of Claims 3, 4, 7, 9, 10, 11, and 12,

wherein said storage unit has a reception schedule storage unit storing a plurality of sets of reception schedule information in said external radio information reception unit, and

wherein said reception schedule control unit controls the reception schedule by selecting reception schedule information of said reception schedule storage unit.

14. An electronic equipment according to any one of Claims 2 to 8,

wherein said internal time correction control unit corrects the internal time by using the estimated correction in case the estimated correction calculated by the correction calculation unit is large and equal to or greater than the correction determination value.

15. An electronic equipment according to any one of Claims 1 to 14,

wherein a plurality of sets of reception timing data and difference data stored in said reception information storage unit are the data of the latest predetermined number out of a plurality of sets of data received in the past.

16. An electronic equipment according to any one of Claims 1 to 15, having a setting changing unit for changing the setting of at least one of each set value and each determination value out of said respective set values and determination values.

17. An electronic equipment according to any one of Claims 1 to 16, comprising a radio wave correction timepiece having a display unit to indicate the internal time measured by said internal time measuring unit.

18. A reception control method of an electric equipment having an external radio information reception unit for receiving external radio information including time information and an internal time measuring unit for measuring the internal time based on the reference clock, comprising:

a time data comparison step of comparing external time data forming time information re-

ceived by said external radio information reception unit with internal time data measured by said internal time measuring unit and outputting the difference therebetween;

a reception information storage step of storing at least a plurality of sets of each data on the timing of receiving the external radio information by said external radio information reception unit and said difference thereof; and  
a control step of controlling reception processing or internal time correction processing based on said plurality of sets of reception timing data and difference data.

a schedule control step of controlling the reception schedule in said external radio information reception unit based on said plurality of sets of reception timing data and difference data stored in said reception information storage unit.

19. A reception control method of an electric equipment according to Claim 18, said control step comprising:

a correction calculation step of calculating an estimated correction by said plurality of sets of reception timing data, difference data, and the elapsed time from the last reception; and  
an internal time correction control step of correcting the internal time by using said estimated correction.

20. A reception control method of an electric equipment according to Claim 19,  
wherein said internal time correction control step corrects the internal time by using said estimated correction in case time information is unsuccessfully acquired when receiving external radio information by said external radio information reception unit.

21. A reception control method of an electric equipment according to Claim 18,  
said control step comprising:

a correction calculation step of calculating an estimated correction by the plurality of sets of reception timing data, difference data, and the elapsed time from the last reception;  
a magnetic field detection step of detecting electromagnetic noise;  
a reception control step of prohibiting reception operation or invalidating reception data by the external radio information reception unit when detecting electromagnetic noise by the magnetic field detection step; and  
an internal time correction control step of correcting the internal time by using the estimated correction when prohibiting the reception operation or invalidating reception data in the reception control step.

22. A reception control method of an electric equipment according to Claim 18,  
said control step comprising:

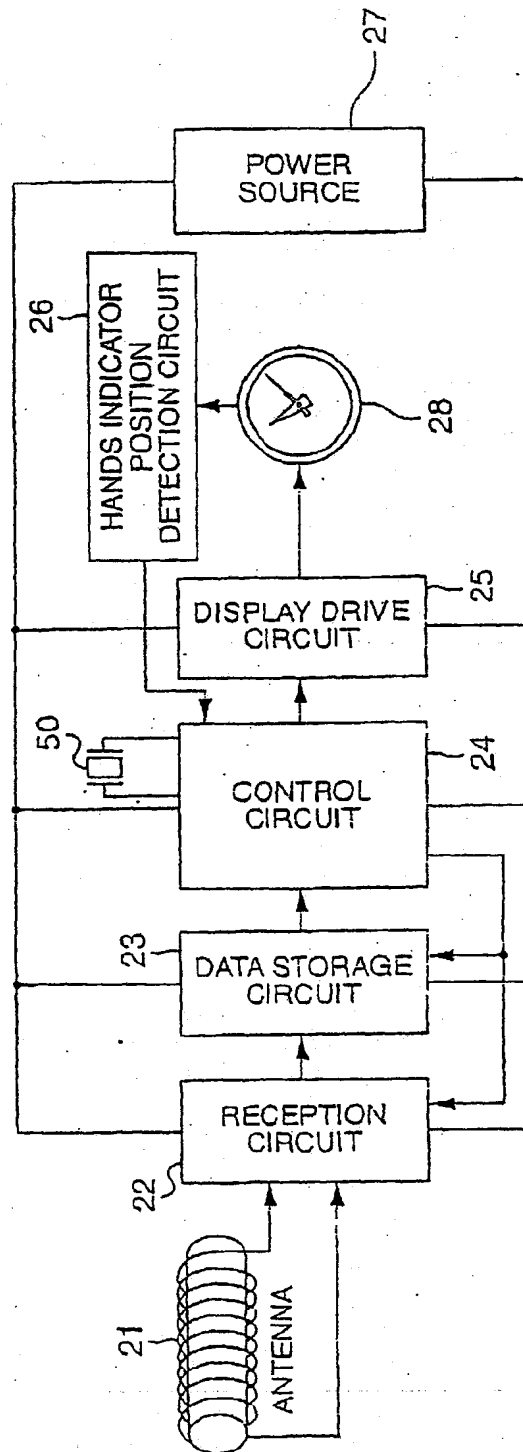


FIG. 1



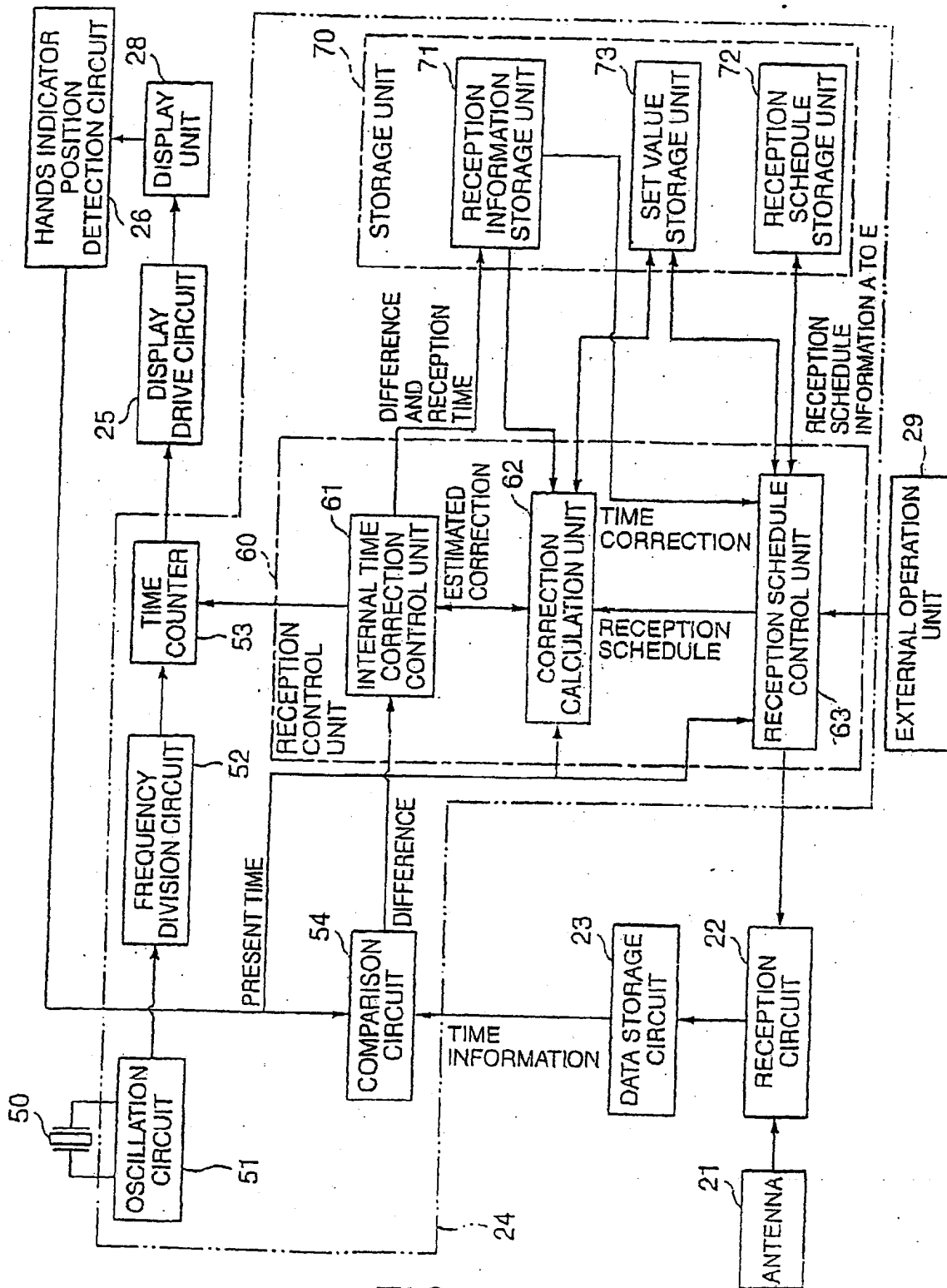


FIG. 2

71

RECEPTION INFORMATION STORAGE UNIT			
	RECEPTION TIMING	DIFFERENCE (SECOND)	TIME CORRECTION (SECOND/DAY)
1	2002/4/1 2:05:00	0.1	0.10
2	2002/4/2 2:05:00	0.08	0.08
3	2002/4/4 2:05:00	0.2	0.10
4	2002/4/5 2:05:00	0.15	0.15
5	2002/4/6 2:05:00	0.2	0.20
6	2002/4/7 2:05:00	0.15	0.15
7	2002/4/8 2:05:00	0.1	0.10
AVERAGE VALUE			0.13

FIG. 3

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RECEPTION SCHEDULE STORAGE UNIT			
SCHEDULE	CONTENT (NUMBER/DAY)	INTERVAL (DAY)	TIME
A	1/1	1	2:00 AM
B	1/2	2	2:00 AM
C	1/3	3	2:00 AM
D	1/4	4	2:00 AM
E	2/1	12 HOURS	2:00 AM
			2:00 PM

FIG. 4

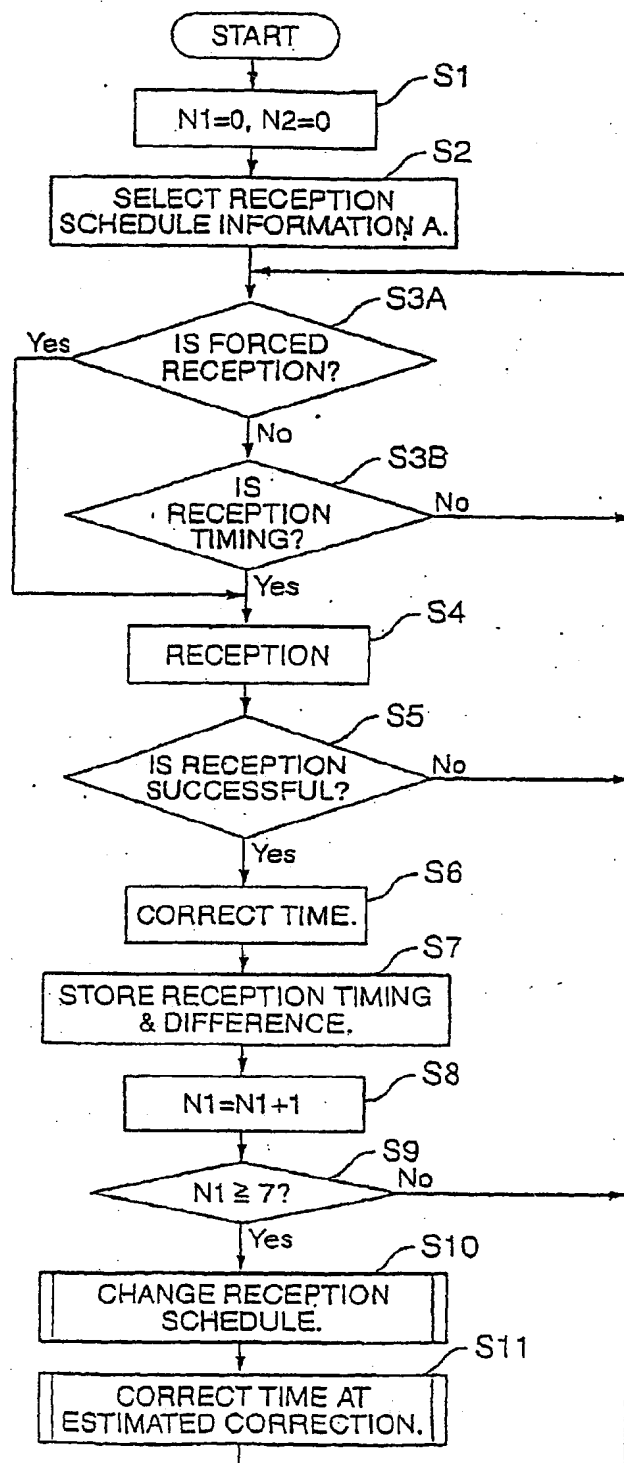


FIG. 5

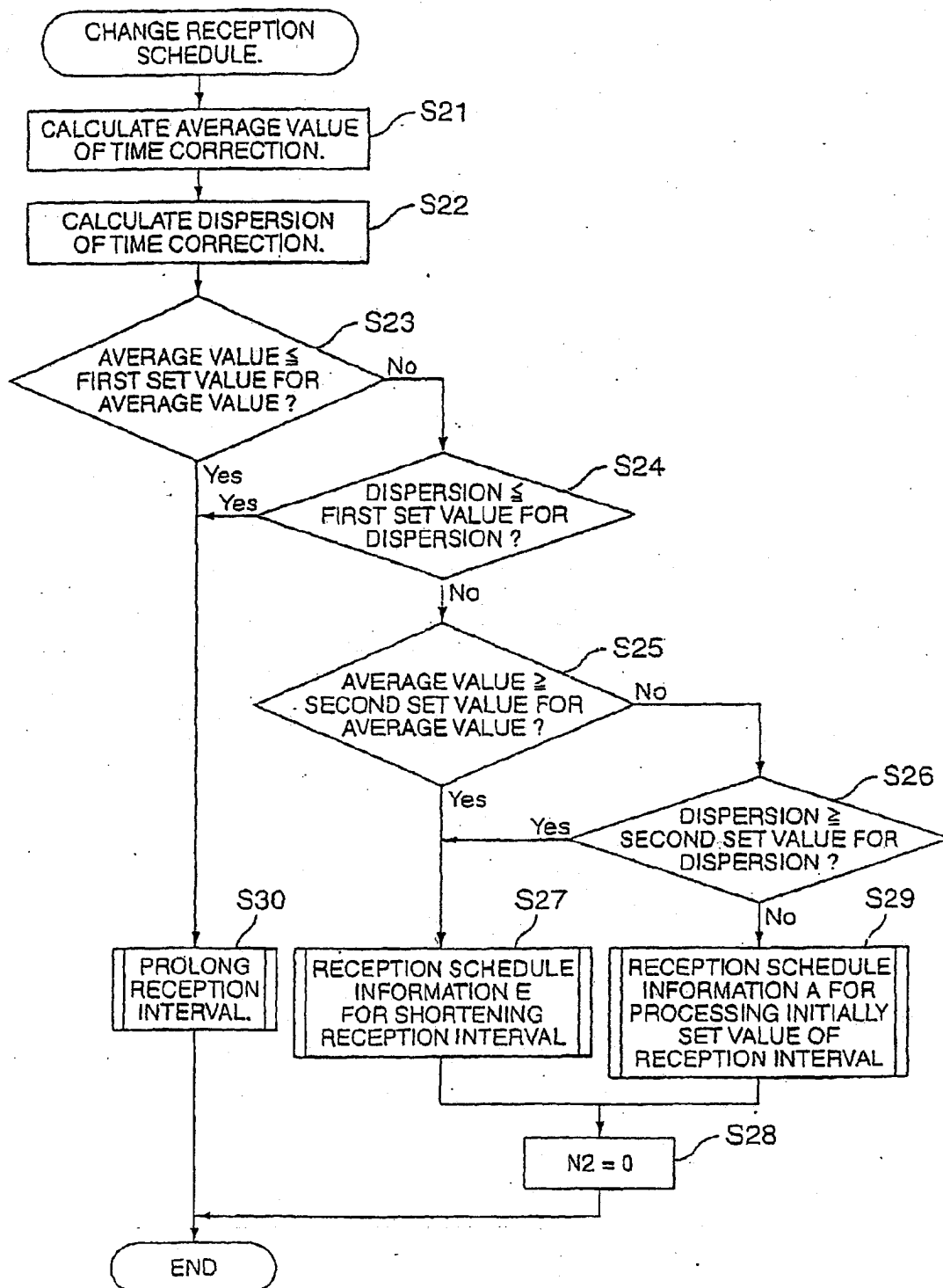


FIG. 6

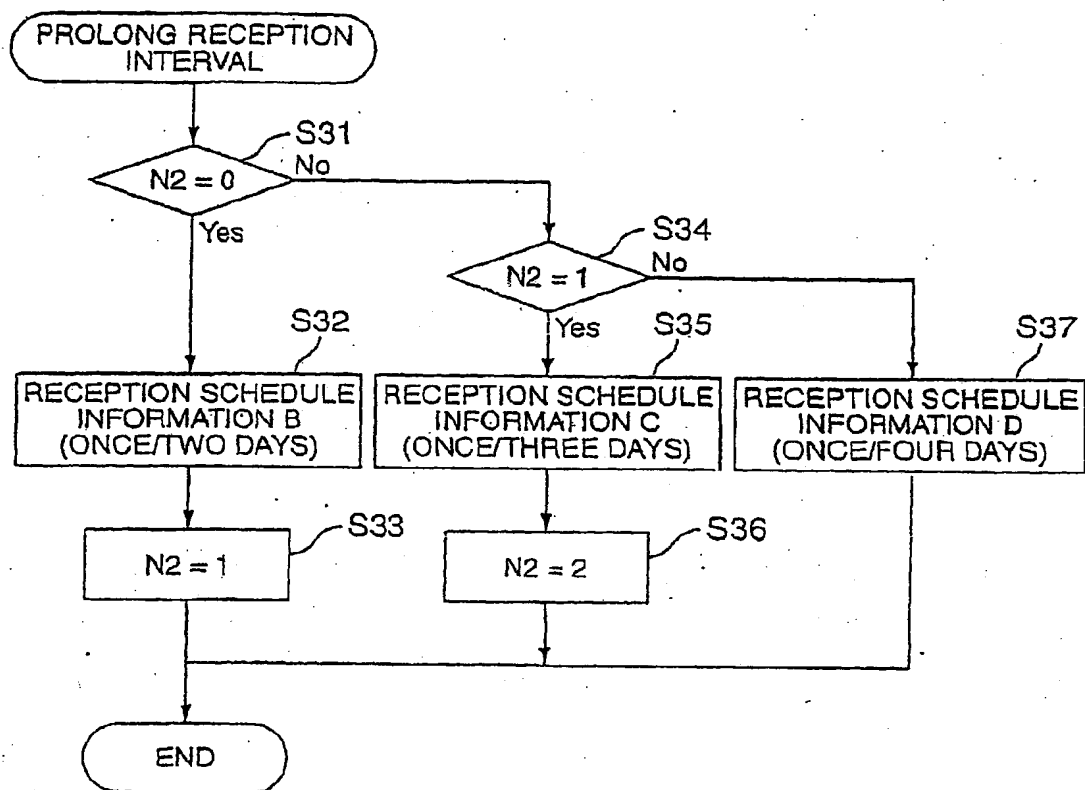


FIG. 7

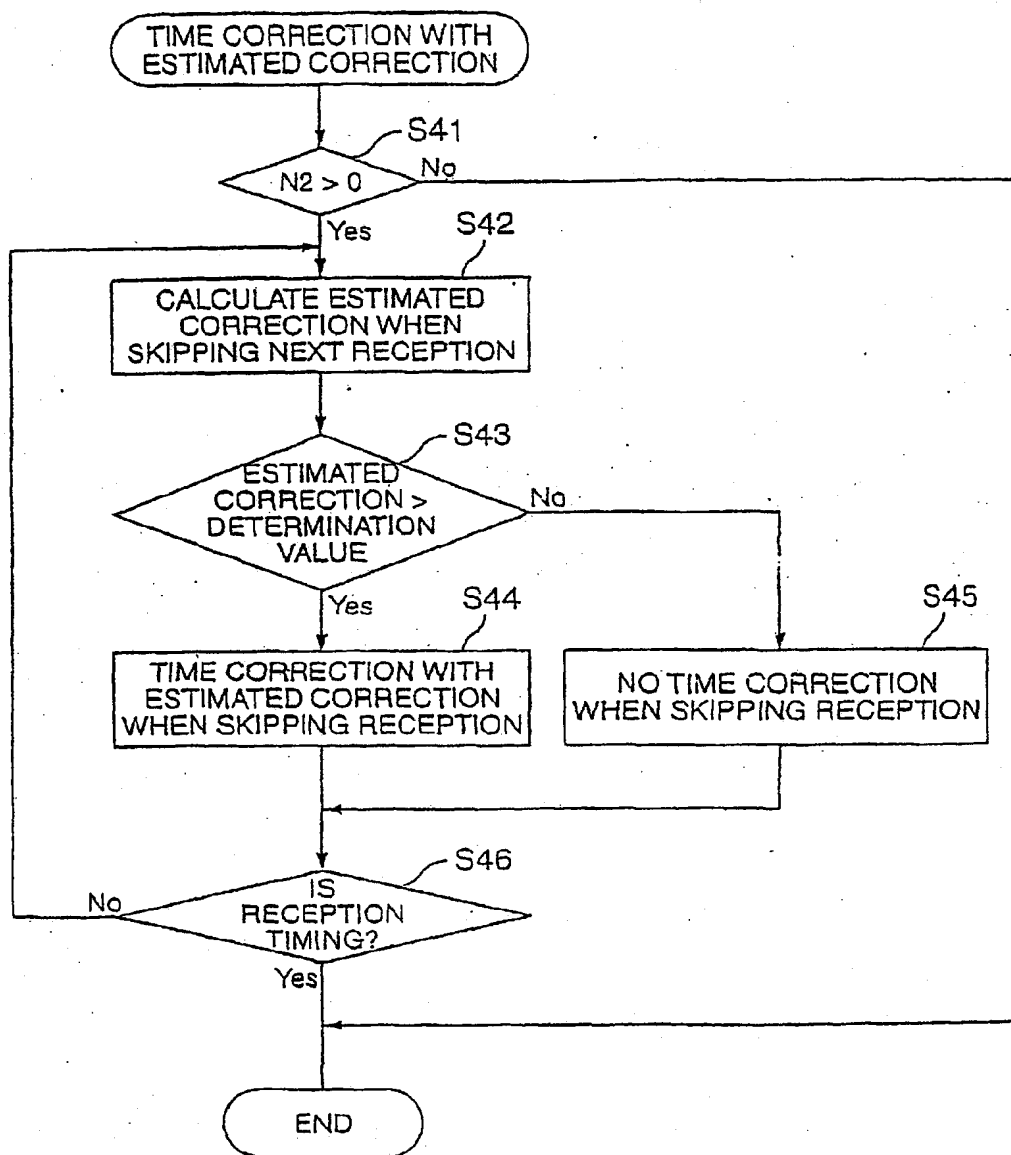


FIG. 8

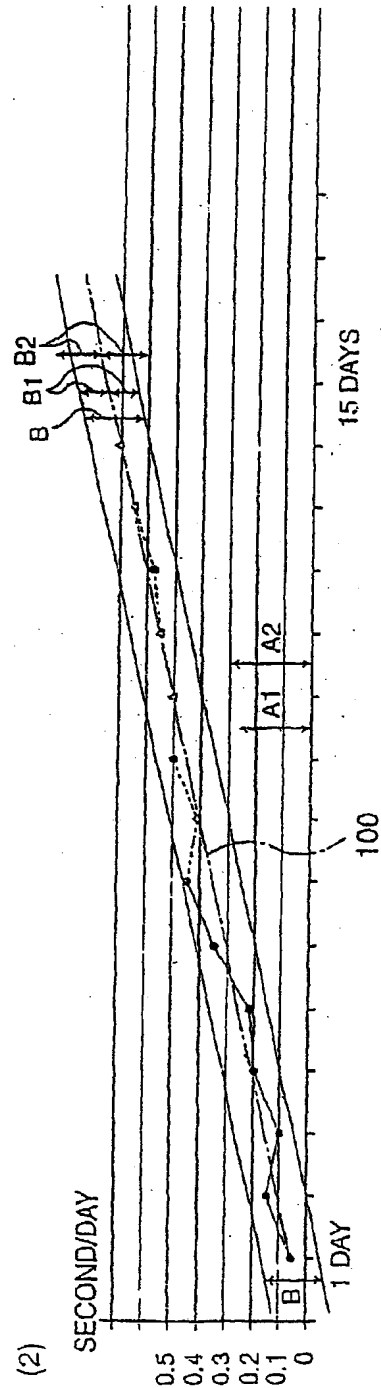
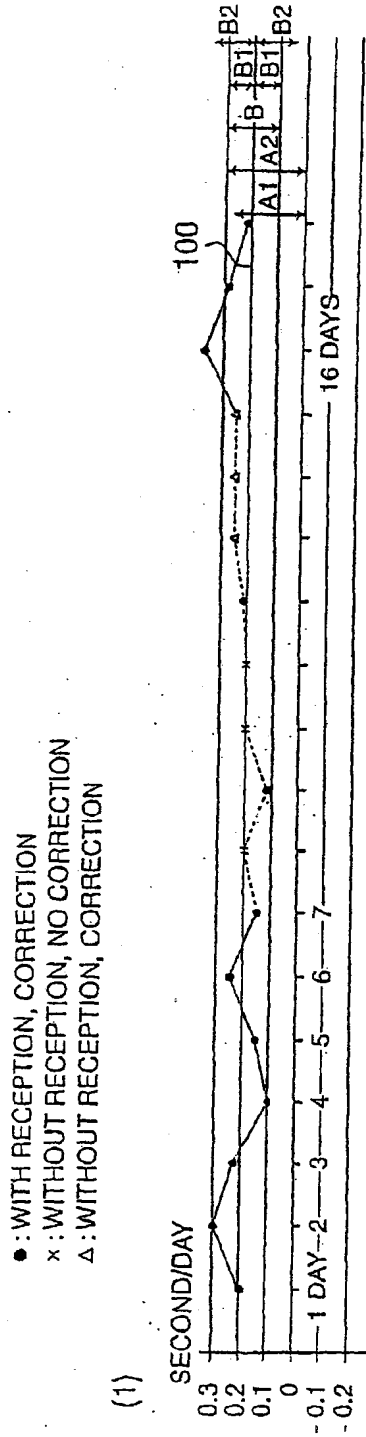


FIG. 9

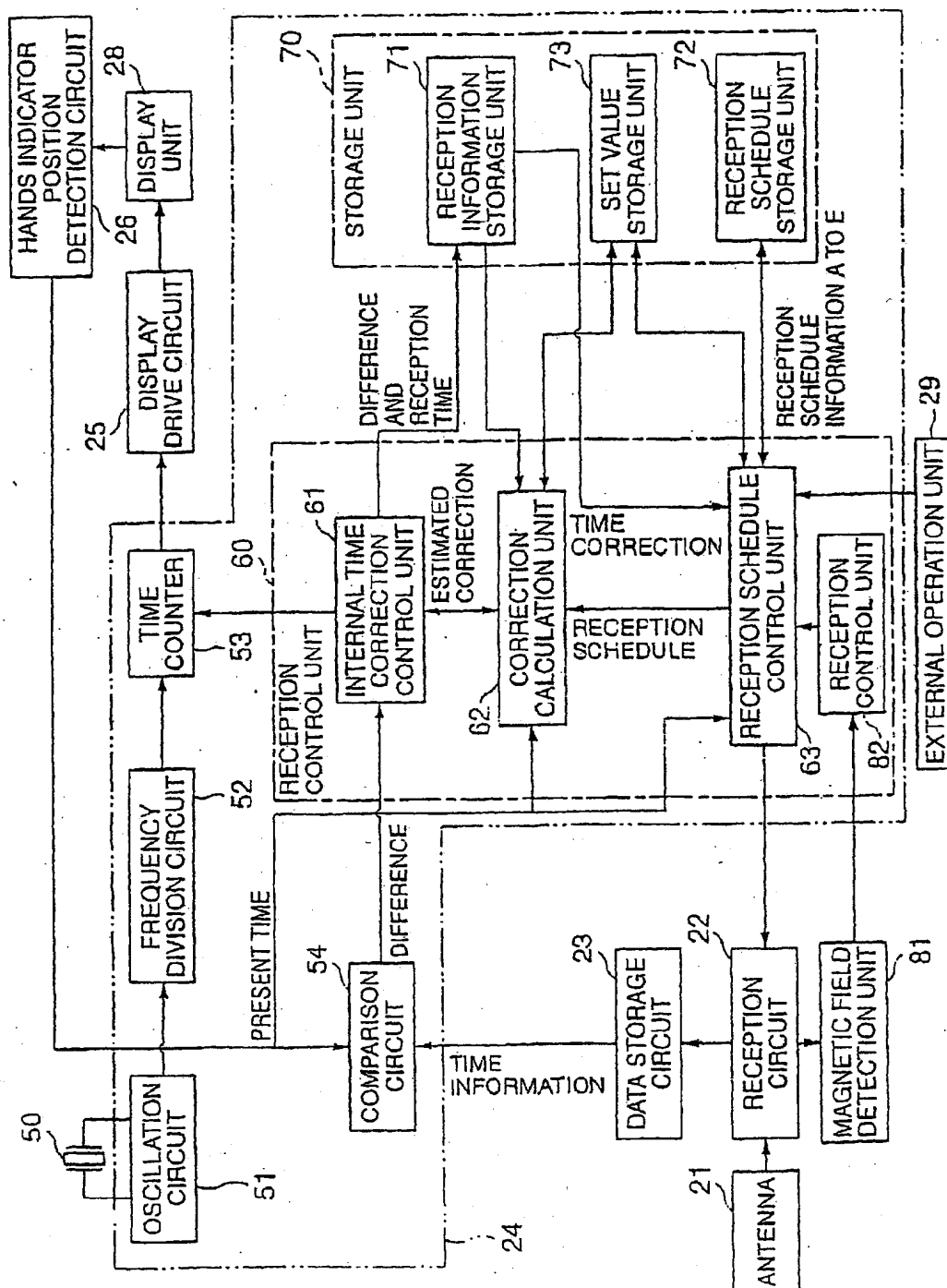


FIG. 10



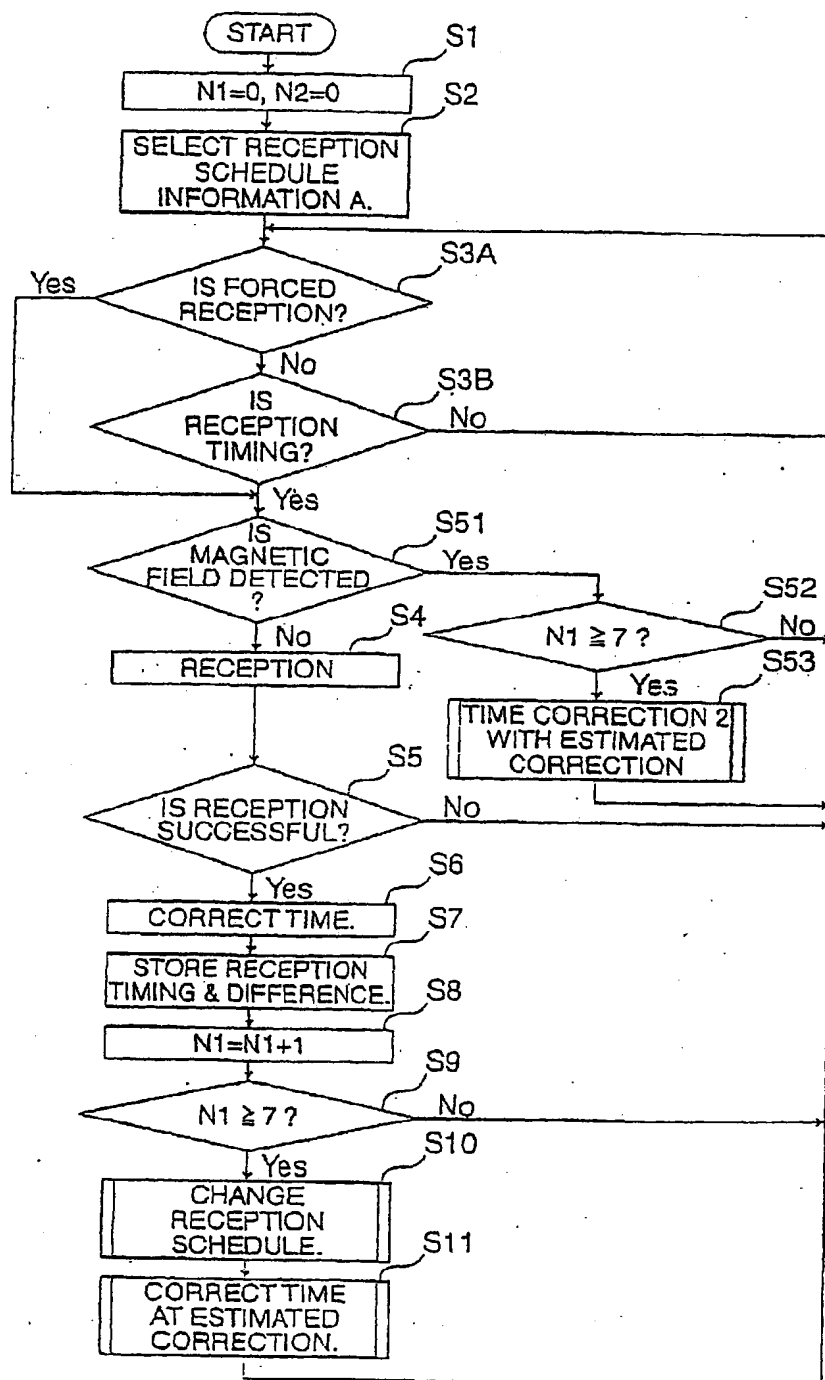


FIG. 11

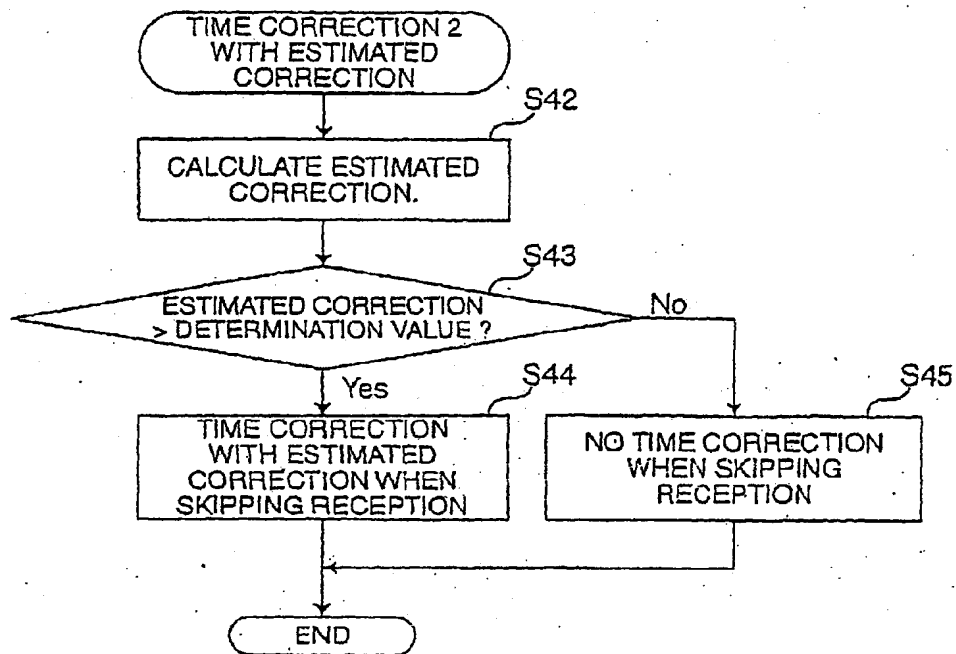


FIG. 12

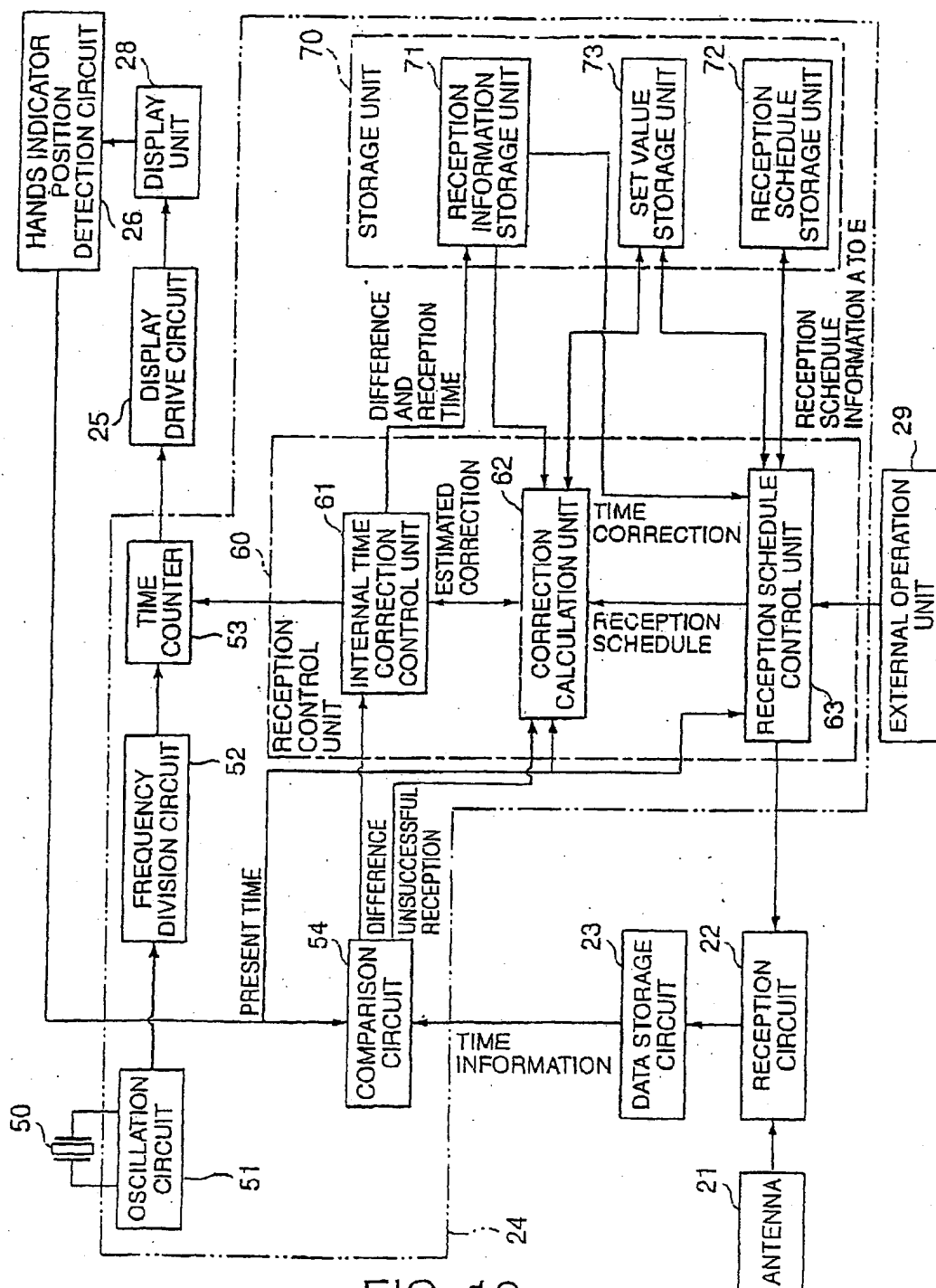


FIG. 13

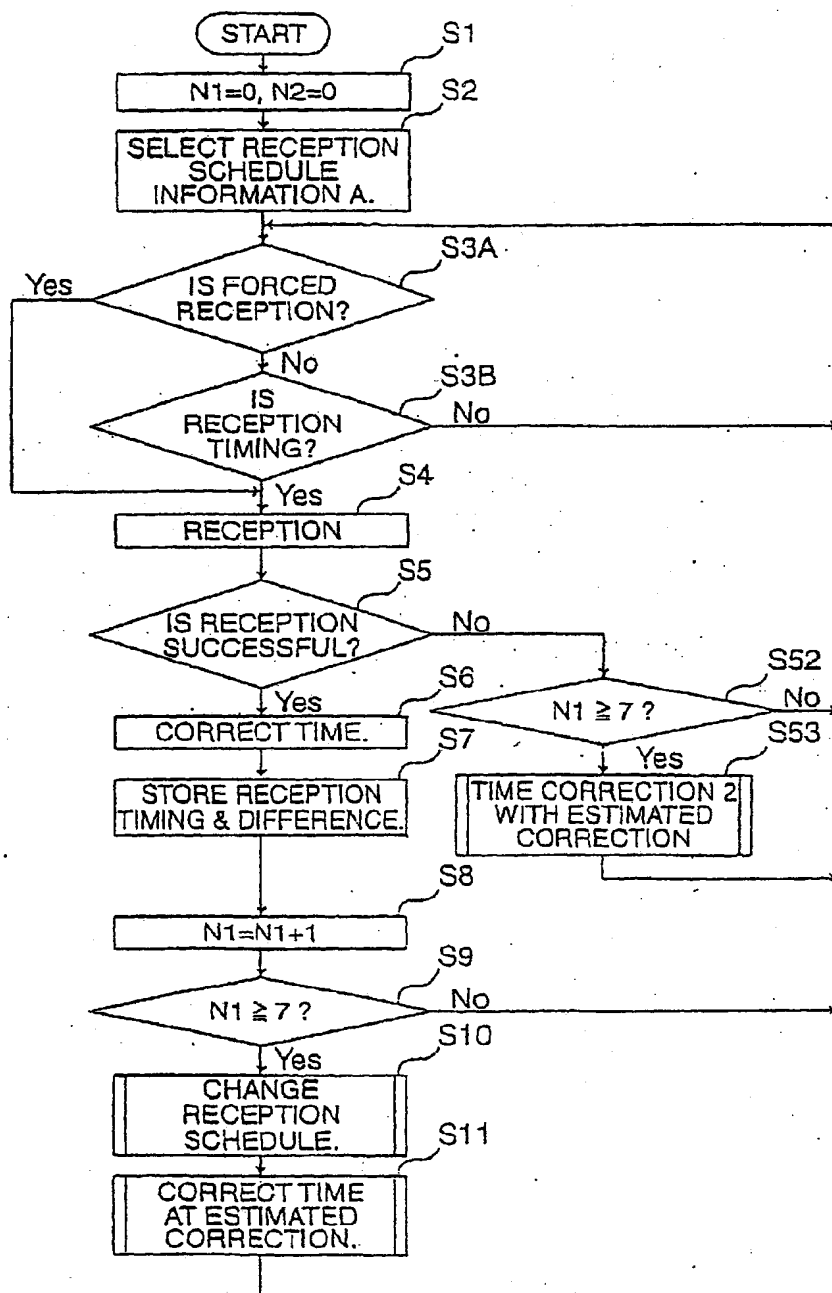


FIG. 14

- : WITH RECEPTION, CORRECTION
- x: WITHOUT RECEPTION, NO CORRECTION
- Δ: WITHOUT RECEPTION, CORRECTION

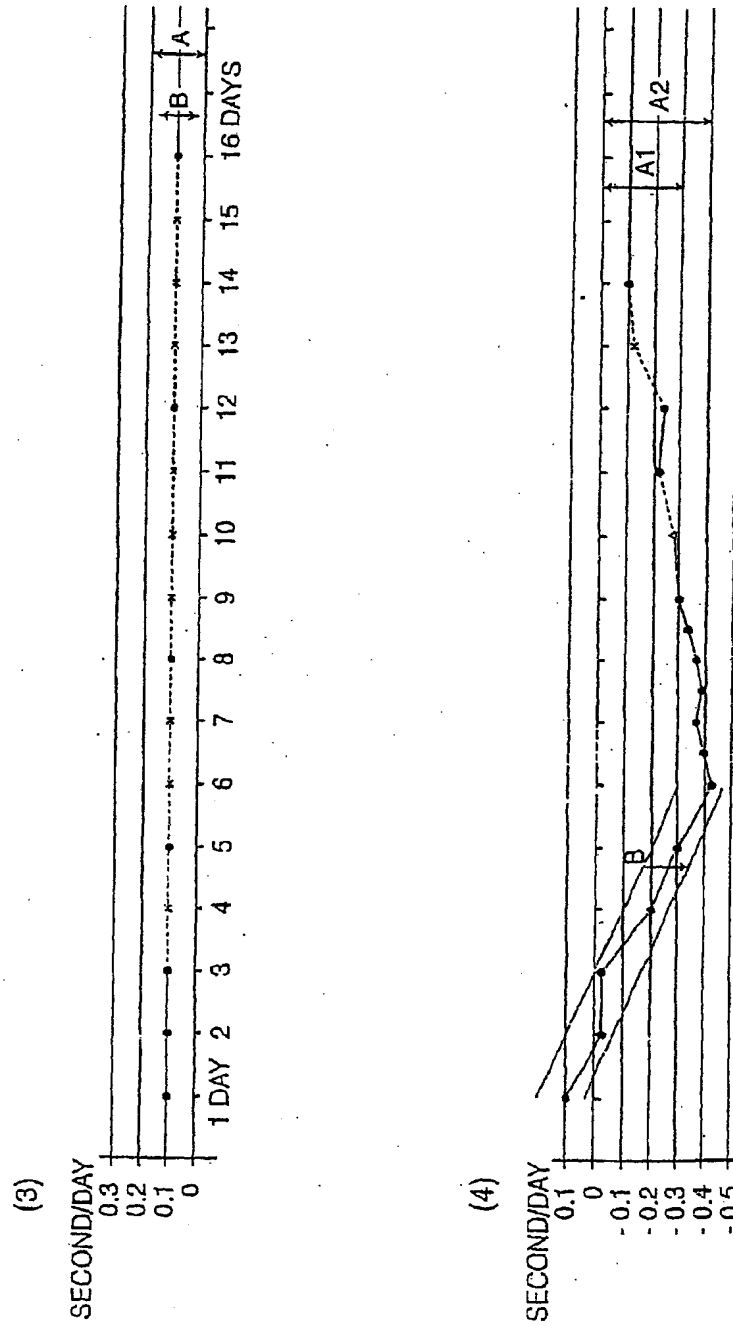


FIG. 15

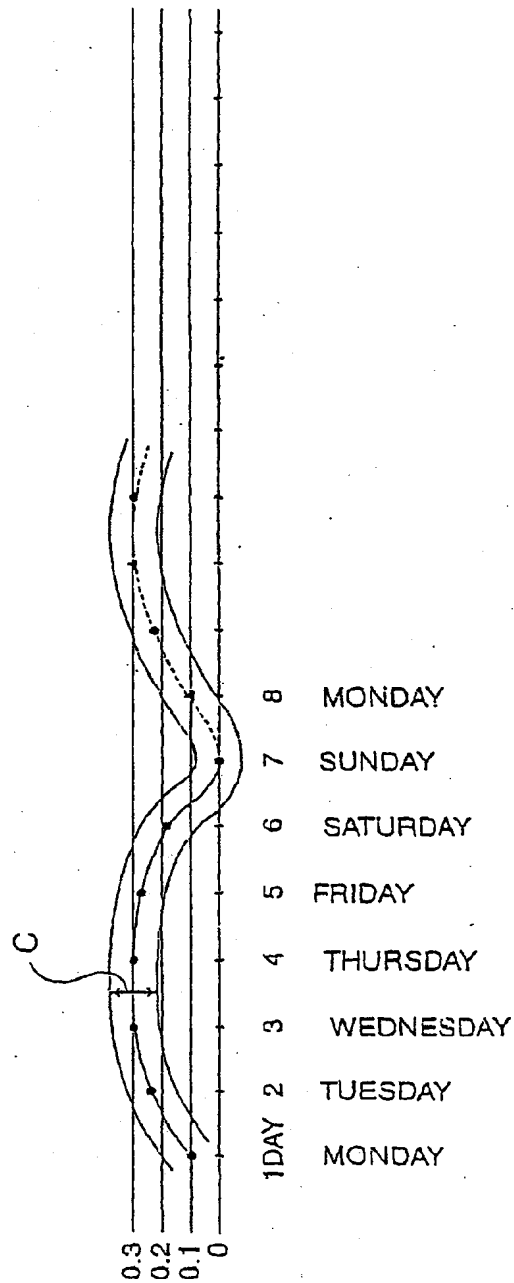


FIG. 16

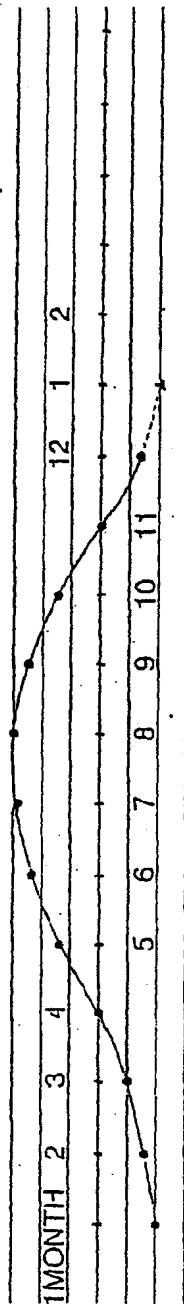


FIG. 17







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**(54) Electronic equipment, and reception control method of electronic equipment**

(57) To provide an electronic equipment capable of outputting substantially correct time data even when correct time information based on external radio information cannot be acquired. A radio wave correction timepiece comprises an antenna 21 for receiving external radio information including time information, a reception circuit 22, and a time counter 53 for counting the internal time. A control circuit 24 of a timepiece comprises a comparison circuit 54 for comparing received external time data with internal time data to output the difference, a reception information storage unit 71 in which at least a plurality of sets of the reception timing of external radio information and each data on the difference are stored, a correction calculation unit 62 for calculating the estimated correction by the plurality of reception timing data, difference data, and the elapsed time from the last reception, and an internal time correction control unit 61 for correcting the internal time using the estimated correction.





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## EUROPEAN SEARCH REPORT

Application Number  
EP 03 25 1381

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			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			G04G
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 7 December 2004	Examiner Exelmans, U
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons -& : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P0401)

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EP 03 25 1381

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82